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ADOPTING EMERGING TECHNOLOGY TO PROMOTE CIRCULAR ECONOMY IN THE BUILT ENVIRONMENT

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Technology has long been regarded to be one of the key drivers of economic growth and a major contributor to a nation's competitiveness. Technology is seen as a significant instrument for increasing the value of a product, project, or service while using the same amount of available resources or capital. Rapid technological improvement and invention have contributed to more efficient and innovative output in a variety of areas, including but not limited to construction, healthcare, energy, tourism, and manufacturing. However, many industries are currently under intense pressure to reduce their use of energy, material, and other non-renewable energy resources. The public and society are also demanding practical solutions for addressing sustainability and climate change issues while also improving people's quality of life. Combining technologies and the circular economy concept within the project life cycle is one approach to tackle these issues.

The circular economy concept is based on using as few resources as possible and ensuring that materials used during, for example, the manufacturing process are reused, recycled, or repurposed before becoming product waste. The concept transforms traditional linear economy, also known as open loop systems, in which materials and available resources are reused rather than disposed away, resulting in a closed loop system that allows waste prevention and pollutant emission reduction. Multiple resources, such as plastic, chemicals, metals, and other substances, are frequently used only once before becoming waste. Through various approaches of design development, manufacturing process, technological adoption, and system modification throughout the product life cycle, the circular economy ensures that these materials are preserved in their optimum value for as long as possible.

Numerous technologies can be employed, combined, and deployed to assist the circular economy throughout the project life cycle. For example, the internet of things (IoT) provided automated big data collection through various sensors, which can be utilized to study people's behavior. In the circular economy phase, artificial intelligence ability to perform many functions while processing unstructured data for further analysis is frequently combined with IoT in facilitating the product movement from consumers back to manufacturers. The technologies enable decision makers to identify methods to tackle complicated problems by using specified criteria, rules, and massive amounts of data. Blockchain, a distributed ledger technology, is currently being incorporated from the design and planning stages to better comprehend asset monitoring and management. It provided major benefits to stakeholders by increasing transparency, improving security, improving traceability, increasing efficiency and speed, and lowering costs. The usage of virtual reality is now also being researched to understand how technology may help to raise public awareness of the circular economy and engage individuals in adopting the principles.

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Furthermore, to aid in the development of these ecosystems, supportive policy design, appropriate financing, and program implementation should be provided. The government public policy should adhere to the principles of circularity. It should be designed to assist and encourage entrepreneurs, organizations, scholars, researchers, government agencies, and other stakeholders to embrace circularity as a new norm for innovating production and consumption systems through technology adoption and new business models. The industrial technology revolution has clearly improved the effectiveness and efficiency of production, management, and governance systems. We believe that research conducted to develop innovative approaches by utilizing emerging technology can promote the advancement of a circular economy while also contributing to tackle sustainability and environmental challenges.

Promoting Research on the Innovation and Technology Development

Research discussing the adoption of innovative technology can help disseminate knowledge on creating new approaches to foster sustainability in the circular economy. In this edition, the CSID Journal of Infrastructure Development presents nine papers in this research area.

The first paper, written by A. Popola, determines the patterns of integrating urban farming into city infrastructure development to improve food security sustainability within city spaces. The finding of this study shows that land allocation and water infrastructure provision can be used to enhance urban agriculture and solve the detected issues related to integrating urban farming and the city infrastructure.

The second paper, written by I.A. Diugwu, M.N. Eneje, H.D. Musa, S.O. Yusuf, and J.D. Njoku, evaluates the relationship between the quality of housing infrastructure and the decision of occupants regarding whether to live the urban areas or move to the peripheries. The findings demonstrated the existence of a significant association between them.

The third paper, written by S. Jadidoleslami and M. Azizi, investigates the importance of constructability in Value Engineering (VE) and provides some suggestions on how to improve constructability with VE. Through the systematic review of the related literature and conducted pattern coding conducted in this study, it was found that the proposed VE solutions covering the principles and concepts of constructability focused on the pre-study and the main study phases of VE and the management subgroup. Some significant areas related to environmental solutions, including cultural and legal issues, need to be further discussed to provide an appropriate context for improving constructability using the VE process.

The fourth paper, written by Y. Sanusi, explores the dimensions of the electricity supply problem; assesses adaptations by households to inadequate electricity supply; examines the use of renewable energy-related facilities; and understands the perception of renewables by households in five residential neighborhoods in Minna, the capital of Niger state. The findings indicate that the city is under a situation of extreme inadequacy of electricity supply, with the domination of fossil fuel-driven plants. Furthermore, the paper claims that a more concerted effort to develop renewable energy to improve the availability of electricity in Nigerian urban centers is high, considering the willingness of households to switch to renewable energy.

The fifth paper, written by L. Nwachi, argues that most urban planning systems in many countries still rely on top-down technocratic plan-making processes rather than a people-led process. Therefore, it aims to evaluate the need for public participation in the plan-making process and to highlight the factors that affect public involvement in the plan-making process. The findings indicate that public participation contributed to the plan-making process by identifying the critical urban issues unique to the specific local areas, establishing priorities, and mobilizing resources to meet the identified needs. It also shows that with public participation in the plan-making

process, the plan implementation can be enhanced as the public tend to be more inclined to accept the plan.

The sixth paper, written by Bothlikar and Nanda, reviews the influence of the COVID -19 pandemic on the real estate industry in India and determines the most impacted real estate segments. The result of this study shows that both residential and commercial sectors have been impacted badly. The residential market has recovered to its pre-COVID level after the first lockdown. Meanwhile, in the commercial market, the pandemic led to many innovations in the office and retail segments, accelerating its recovery. On the other hand, the hospitality segment was the worst-hit segment as tourism has effectively stopped.

The seventh paper, written by V. Arteeva and A. Skhvediani, analyzes and systematizes the indicators for assessing the performance of construction companies and projects through a bibliographic review. The results revealed that the satisfaction of all parties involved in a project's construction and operation processes is crucial for the performance indicators of construction organizations and projects.

The eighth paper, written by A. Yuan, D. Pinka, and E. Setyowati, assesses the quality of Solar Home Systems (SHS) installation, the electrification situation, and the usage of the SHS to improve existing and future SHS implementation. The finding of this study shows that the electrification ratio was increasing fast, and SHS has a positive economic impact compared to diesel gen-sets. However, small failures could lead to SHS no longer being used. Therefore, active service is key to increasing working SHS and improving usage; the local people must be trained to improve its usability and decrease its failure.

The ninth paper, written by H. Saputra, F. Azizan, N. Fahmi, integrates Unmanned Aerial Vehicle (UAV) in the Building Information Modelling (BIM) as a technique to digitize building documentation as a 3D model by taking into account a lodging property as the case study. The evaluation test done on the BIM model developed by the BIM-UAV approach confirms the high accuracy of this integration.

We hope this edition may convey new insight and knowledge that benefit our readers. We welcome any comments or inquiries that you may have concerning the direction and the content of this journal. We invite you to join our venture by sending your work for future consideration.

Warmest regards from the Editorial Office,

Prof. Mohammed Ali Berawi
Editor-in-Chief

Mustika Sari
Managing Editor

Perdana Miraj
Managing Editor

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INTEGRATION OF URBAN FARMING INTO CITY INFRASTRUCTURE DEVELOPMENT

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ABSTRACT

The ability to respond to the need for food is threatened by the scarcity of urban farmers (UF) in the elevation of the urban population. This shows that the availability of food is a cultivated land function, indicating that agriculture is only a mirage when sites are unavailable for farming. Irrespective of these conditions, the sustainability of food production within the city spaces is still the complimentary urban infrastructure enhancing the movement of goods and farmers. Therefore, this study aims to determine the patterns of integrating urban farming into city infrastructure development. In this case, a mixed methods approach was used, with a sample of 236 UF obtained across five local government areas (LGA) of Ibadan metropolis, Nigeria, due to the land availability that ranked first in the urban agriculture (UA) location within the city. Based on interviews with selected farmers and literature reviews, many UF preferred to have their farmlands located along the road for ease of mobility and access. The results showed that old age limited farming travel distance, with several cases of farm produce theft, subsequently detected. To solve these issues, land allocation and water infrastructure provision including irrigation kits were needed for the enhancement of UA and UF, respectively. In addition, comprehensive plans integrating UF infrastructure spaces were suggested.

Keywords: Agriculture; City Spaces; Land Access; Urban Infrastructure

1. INTRODUCTION

Many African countries are endowed with land for food production, although the urban land scarcity for urban farmers (UF) is a common challenge. According to Jayne et al. (2014), some African countries were blessed with farming lands, although had fewer engagement capacities. The emerging and increasing urbanization representing residential, commercial, and industrial land-uses expansion in this continent, has also limited the potentiality of UA (urban agriculture) within its cities. This is due to the decrease in agricultural land, regarding land-use conversion unplanned urbanization and site degradation (Fischer & Shah, 2010; Jayne et al., 2014). Arable farmlands are presently shrinking based on these urbanization and degradation processes. As urbanized land likely to be doubled by 2030 (Seto et al., 2012), Alexandratos & Bruinsma (2012) predicted the development of annual crop yield to be less than 1% over the next decade.

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It also predicted very limited space for the expansion of arable land. This showed that urbanization, food demand increase, climate change, site degradation, as well as resource decline and pressure were expected to cause a shortage of land in 2050 (Roeffen et al., 2013), indicating a great challenge for agriculture. Based on Headey & Jayne (2014) and Jayne et al. (2014), an analysis of changes in agricultural farm sizes was provided among some African countries. This indicated that the land constrained for farming experienced an average reduction of two hectares across the continent.

In Nigeria, the median farm size declined from 2.5 and 1.4 ha in 1994 and 2010, respectively, to 0.85 ha in 2013 (Headey & Jayne, 2014; FAO, 2017). According to Atu et al. (2012), urban sprawl was a common event and remains one of the greatest threats confronting agricultural lands in this country. Land uses such as residential, commercial, recreational, industrial, institutional, and religious spaces, are also provided with greater priorities when physical development plans are prepared by various planning authorities. In this case, Abiodun and Bayode (2014) asserted that the land development rate in the Ibadan metropolis was fast outstripping the population density, due to excessive site consumption. Between 1990 and 2013, the population of this city approximately increased by 19%, with the land development rate also elevating from 42% (1989) to 61 and 70% in 2000 and 2013, respectively. In addition, the per-capita land consumption has exceptionally increased over three decades, based on the utilization of sites for development initiatives, which emphasized commercial, industrial, educational, recreational, and residential purposes. According to Wahab et al. (2018), 3 out of every 5 UF were displaced from their previous farming locations, due to the urban land scarcity for UPA. This continuous decrease in the availability of UA land is inimical to the sustainable urban agriculture and food security in Ibadan, compared to other developmental activity areas.

These conditions explain the peculiarity of land scarcity, with the choice of farming location often emphasizing city infrastructures. This is due to the relevance of the infrastructures, such as roads, water, and conventional urban farming gadget, to the city's food system functioning. Mougeot (2000) also advocated for innovative and optimal planning for city food system, which is dependent on infrastructure and service. Based on Davies et al. (2021), Steenkamp et al. (2021), and Sesan et al. (2022), city design and governance need to be inclined toward food security. This is essential for a balanced symbiotic relationship between urban farming and city infrastructure development. It is also important in stating the urban agriculture and infrastructure nexus towards sustainable food security within the city center.

2. METHODS

This experiment was carried out in the traditional city of Ibadan, which is one of the major urban centers in Nigeria. The city has a land area of 3,123.30 km², where the urban local government area occupies about 463.33km². It also contains five urban and six peri-urban local government areas (LGAs), respectively. A survey of 236 UF was carried out across the five metropolitan LGAs of Ibadan North, North-East, North-West, South-East, and South-West. Moreover, data was obtained using questionnaires, interviews, and field observation. In this case, the questionnaire was administered to the farmers through mixed methods of purposive, snowball and convenience sampling techniques. After obtaining the sample size of 236 participants, the time frame, ease of UF access, and the clustering of farmers along purposively identified locations were also essentially considered.

The integration of urban agriculture into city planning was carried out using global case study experiences. The deductive reasoning of this planning process was also explored and integrated into the development of inclusive spaces for all land uses. This was conducted through a systematic literature review on cities and food systems. The question guiding this experiment also

emphasized the patterns by which city farming and infrastructure were integrated into an urban configuration, for sustainable food system planning.

3. RESULTS AND DISCUSSION

3.1. Questionnaire Results

Table 1 shows that the majority (92.3%) of the farmers have farmland sizes fewer than 5 ha. From the entire sampled UF, 50.8, 41.5, 3.0, and 4.7% have farm sizes fewer than 1 ha, between 1-5 and 6-10 ha, and over 11 ha, respectively.

Table 1 City Farming Characteristic in Ibadan

Farmland size			**Food production sales**		
Farm size	No. of UF	%	**Do you sell within the city?**	Farmers' response	%
Less than 1 Hectare	120	50.8	Yes	82	34.7
1-5 Ha	98	41.5	No	154	65.3
6-10 Ha	7	3.0	Total Response	236	100.0
Above 11 Ha	11	4.7			

Factors influencing urban agriculture												
Response	**Home environment**		**Nearness to road**		**Nearness to the source of water**		**Availability of land**		**Nearness to market**		**Secured location**	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Agree	173	73.3	127	53.8	155	65.7	201	85.2	118	50	134	56.8
Disagree	63	26.7	109	46.2	81	34.3	35	14.8	118	50	102	43.2
Total	236	100	236	100	236	100	236	100	236	100	236	100

Based on Table 1, 73.3 and 53.3% of the total participants agreed that home and road environment served as factors influencing urban agriculture (UA). A total of 65.7, 85.2, 56.8, and 50% also agreed that nearness to the source of water, land availability, secured location, and market influenced UA, respectively. These results indicated that land availability, home environment, as well as nearness to the source of water, secured location, road, and market were the motivational factors influencing UA location. Regarding the point of sale, 34.7 and 65.3% sold their products within and outside the Ibadan city market, respectively (See Table 1).

3.2. Interview Results

Agriculture is possibly carried out through the possession of cultivated land, where food and farming are not a mirage. In this case, the urban densification causing different utilization of land was no longer innovative. According to Ezendinma & Chikuezi (1999) and Ajadi et al. (2011), the choices of "what, where, and how to produce" was determined by the culture, traditions, market, water supply, rainfall, climate, sun exposure, soil condition, plot size (land), and home distance. This proved that farmlands were often close to residential areas. Based on an interview with one of the farmers, the following was reported: "*…many of us are old, so the difficulty in travelling far is not good for old age… and many of our children are not interested in farming…*"

From this interview, farmers were not willing to travel a long distance from farms to residences. This showed that the closeness of the farm to their homes enabled easier arrival and departure, as well as appropriate monitoring processes. The ease of marketing is a very important factor in farm locations, whose security is also very essential when considering animal husbandry. In addition, the fear of theft and loss of animals to hoodlums is subsequently part of the important

factors influencing animal farmers. In this case, an urban farmer reported the following: *"... I opted for a smaller plot size following the theft of my farm produce in the last planting season."*

According to Tunde & Adeniyi (2012), transport affected agricultural marketing due to being the only medium eligible for farmers to mobilize their products to the market. It indicated that the difficulty in the product mobilization led to multiple on-farm sales as illustrated in Figure 1.

Figure 1 On-farm sales of produce at Eleyele floodplain (2018)

The closeness of farmlands to markets is very important when handling perishable goods and vegetables. For farmers, these sales locations outside Ibadan include Lagos, Osun, Kwara, and Ogun states. In this case, these states' supply choices emphasized the demand of the buyers, which often arrive at the farmland to buy and transport back home. Based on a vegetable farmer and trader, more profits were generated from the street hawking carried out by the children within their residential neighborhoods. For those selling within Ibadan, several factors were identified, namely transportation cost and constraint, farmers' preference based on market knowledge and small-scale production, as well as high product demand. This indicated that supply was often carried out near city neighborhoods when not on-farm, especially in Bodija, Shasha, Gbagi, Ojoo, Sango, and Iwo-road markets.

According to Lanarc-Golder (2013), UF were arguably closer to the market, other farmers, and supportive city organizations. This enabled them to share training and resources, as well as collaborate with others to reach wider audiences. One of the most direct benefits of internal and external food development was the new source of products and valuable people for local communities. Petit et al. (2011) also identified road as a disadvantage to the quality of UF food products. This was observed in city feeding and the additional value provided by urban farming. Furthermore, Taiwo (2013) stated that road access was critical to the maintenance of UF profitability, indicating that farmers cherished the need for easy access to city farms, which were mostly located along vacant plots. Based on FAO (2017) and van Veenhuizen (2014), the development often characterized by cut and fill was temporarily or permanently optimized for urban farming. This proved that degenerated residential, office or industrial areas were demolished, leading to the development of new open spaces liable to remain vacant for a long time. New roads and power lines were also designed, enabling the development of new vacant open spaces. Therefore, these developmental occurrences prioritized the balancing and syncing of city farming and project.

3.3. Sustainable Agriculture within a Sustainable City

A sustainable system is one of the most compelling challenges of the 21st century, where food is an ideal medium for designing manageable urban, rural, or peri-urban locations due to the systematic multi-functional character. In this process, food planning is presently uniting people from a diverse range of backgrounds, including planners, policymakers, politicians, designers, health professionals, environmentalists, farmers, traders, and civil society activists (ISOCARP, 2015). This confirmed that urban planners need to understand the methods and strategies of food production, to achieve a sustainable system and city. Sustainability is described as a dynamic equilibrium in the interactive processes between a population and the carrying capacity of an environment. In this process, the population development expresses its full potential without adversely and irreversibly affecting the reliant environmental capacity (Stivers et al., 1976; Meadows and Randers 2004). It is also a function of ecological, economic, social and technological themes (Hasna, 2007). Moreover, sustainability encompasses environmental (stability of physical and biological systems), economic (capital base, income, and wealth distribution among generations), and social (vulnerability reduction, social and cultural system maintenance, and the ability to withstand shocks) city components (Ciegis et al., 2009).

A sustainable city is a location where citizens are able to meet their needs without endangering the well-being of the ecosystem, as well as the present and future living conditions of other people (Roseland, 1997). Sustainable agriculture also contains environmentally friendly methods of farming, which allow the production of livestock and/or crops without damage to the natural or human systems (Falk, 2013). In this context, a sustainable city provides adequate knowledge and opportunities to promote manageable UA, with urban de-concentration continuously mobilizing into the third century. This emphasized the development of new landscapes to provide healthy living systems, compared to the prevention of urban malfunctions (Grady, 1994). When urbanization is adequately managed, peri-urban agriculture is likely to be preserved. This contributed to strengthening the city's economic base, enhancing social cohesion, and blocking open ecological loops (Tricker, 2012).

According to Andriatiana et al. (2012), the challenge globally confronting agriculture prioritized the production pattern of food for the increasing world population. This was projected to reach nine billion people in 2050 while conserving the environment. In developing a comprehensive and sustainable approach for the African agricultural sector, the nitty-gritty of the problems needs to be nationally understood and addressed (Afolabi, 2004). This explained that the sustenance of a beneficial approach emphasized the intensification of agriculture, which entailed the use of economic and environmental agricultural practices. These conditions were carried out to address the global food insecurity caused by continuous population increase, agricultural land loss, and environmental degradation, which had a long-term effect on the global farming system (Simon et al., 2013).

Based on Lwasa et al. (2011), food production space was one of the major limitations for urban and peri-urban agriculture in densely urbanized areas, especially in slum and squatter settlements. This was either not readily available or limited in the area. In addition, the non-incorporation in city planning and land tenure conflict was major factor for this inadequacy. Pothukuchi and Kaufman (2000) also identified five patterns by which urban planners strengthened the food system, namely (1) Data compilation on community food systems, (2) Relationship analysis between food and other planning concerns, (3) Assessment of the present planning effect on the local food system, (4) Food security integration into community goals, and (5) Future planners' education about food system issues. This proved that food, as a discipline, was inseparable from planning, whose relevance helped in the development and protection of internal and external

spaces (White and Natelson, 2012). Cities were also historically developed around the supply and distribution of food (Steel 2008), due to the dependence on urban infrastructure.

3.4. Urban Infrastructure and Urban Farming

Urban farming remains an integral part of the city landscape, whose relevance is unable to be downplayed as a part of the spatial configuration of cities. Despite this, resilient and sustainable food production remains limited within urban areas, due to the neglected infrastructural planning for farming and urbanization. According to Lin et al. (2017), urbanization was continuously a major limitation of conventional urban farming. This showed that future city expansion should consider the need for UA to be integrated into urban land and green infrastructure planning, with adequate food production within city spaces.

Based on Maxwell (1994), UA formed a crucial coping mechanism for the urban poor, although its impact on the service infrastructure was extensively emphasized. This was to ascertain the extent to which it influenced the failure of such services. Mbusya (2013) also highlighted that uncoordinated UA in the planning or city arrangement led to urban infrastructure decay and service disruption. This identified that a regulated and balanced UA planning was characterized as water irrigation, reticulation infrastructure, fewer transportation interference, electricity, and waste amenities as indicated in Figure 2. Since water is a necessity for UA, urban farmers are subjected to floodplains and several sources, such as illegal irrigation connections, which often destroy the flow lanes. For instance, sewage lines are often distorted to accommodate framing nutrients on farmlands. This prompted a mixed utilization of infrastructure within the land use schemes (Leh et al., 2011).

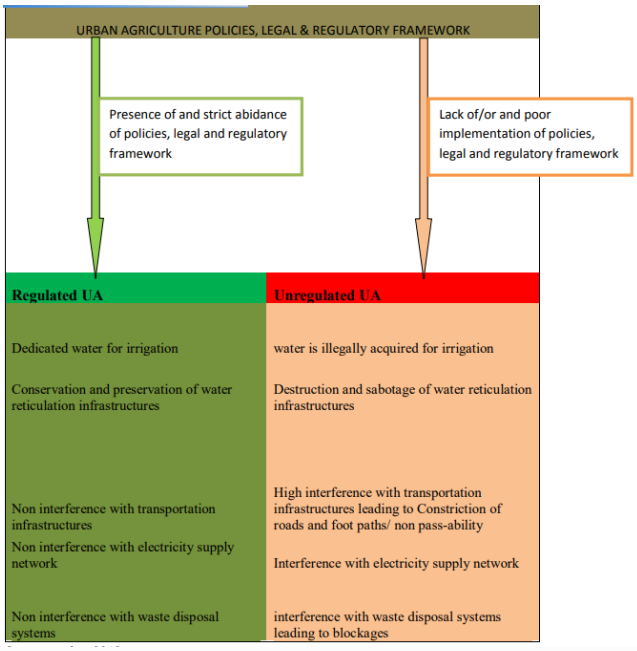

Figure 2 A balanced urban agriculture and city infrastructure planning model (Mbusya, 2013)

According to the Whyfiles of the University of Wisconsin Board of Regents (2017), floodplain and levees management, as well as channel construction were arguably critical to the social inclusion of the farmers. This indicated that close residence to rivers and urban floodplain management are important to farming and food production. Buttressing also emphasizes the need

for UF infrastructure responsiveness towards enhancing urban food security (Bricas and Conare, 2019). In addition, Taguchi & Santini (2019) highlighted cities were promoting vertical farms, as well as stacking layers of gardening and farming activities in a building and underground site. This subsequently enabled the development of tunnel vegetables. In some cases, the vertical economy supporting water harvesting systems and facilities was constructional and infrastructural for urban farming (Despommier, 2019).

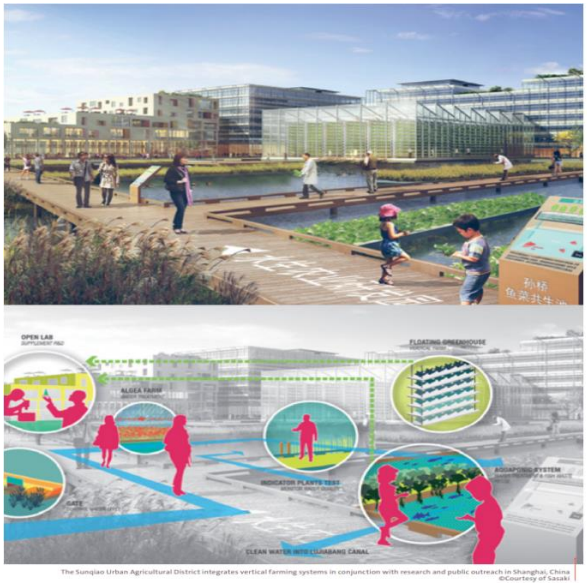

Figure 3 Vertical Farming within the city infrastructure in Sunqiao District, China (Despommier, 2019)

According to Pauleit et al. (2019), city densification and contemporary smart development greatly increased urban resilience and food security in Jakarta and Addis Ababa. The implementation of these strategies led to lower losses of green infrastructure and its ecosystem services, such as food provisioning, the urban heat island effect reduction, and the flooding risk during rainstorms. This indicated that urban planning should concentrate on devising and implementing strategic key measures at city and regional scales, such as the allocation of metropolitan centers and infrastructures, as well as outlining the location of green facility conservation as a lifeline. In this case, the role of integrating and improving coordination was important in achieving urban food production among several professionals, such as agronomy and food engineers, drivers, and managers. This is due to the importance of their cooperation in managing urban food system vulnerability.

Based on Amusat & Amusat (2013) and Wahab & Popoola (2018), farm losses to city disasters were not underplayed. This indicated that farmers lost about ₦350000 (1000USD) to flooding along the urban and peri-urban corridor of Ibadan city. Agbola et al. (2012) also reported that several urban farmers lost many agricultural products, such as fish, poultry, and crops, during the historic flood occurrence in August 2011. This was due to the absence of specific management policies, especially for water channels and the waste disposal behavior of the city residents. It also stated that only the Ogunpa river was channelized in the city, including the dredging and construction of concrete embankments (Agbola et al., 2012). Furthermore, Gould et al. (2020) iterated that coastal flooding contributed to short and long-term farm losses in the United Kingdom, where an average of £255 was lost on a hectare of land (Penning‐Rowsell, 2013). In the Western Massachusetts and Vermont areas of the USA, an estimated 15,400 acres of farmland

with a cost of 20 million US dollars was also destroyed by storm (Warner et al., 2017). This was in line with Dubbeling et al. (2019), where urban flooding, infrastructure, market, food insecurity, neighborhood shocks and coordination were identified as the extreme weather vulnerabilities against urban food production. The need for improved access to water infrastructure, roads, river channelization projects, and integrated urban agriculture masterplan was also imperative towards the reduction of farm loss, due to several city disasters such as flooding.

4. CONCLUSION

Based on the results, the family division of labor existed among urban farming households, as children are often tasked to engage in trading activities. Farmers also preferred to carry out farm activities near their homes, due to security demands and old age considerations. In this context, some threats were identified toward urban farming, regarding the oldness of farmers and the unwillingness of children to engage in farm activities. However, the reasons for these threats were not investigated.

The relevance of water accessibility also led to the need for irrigation support and open field supply by the government, for the urban farmlands along the upland region. From the results, vegetable farmers' quest for land along the floodplain areas, where irrigation farming was easy. To limit the loss and produce monopoly by warehouse traders, a need for the government to control the sale and purchase of the farm products was also observed, to increase UF profits. In addition, an improved allocation of space for urban farming was needed in Ibadan and other cities. The integration of the city towards sustainable production was also achieved through a comprehensive planning process, which supported and identified food cultivation within the urban center. Based on these results, the relevance of urban policy and tools, including UA and UF, is very important for the holistic management of urbanization within the city.

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PERCEPTION OF HOUSING QUALITY BY HOUSEHOLDS IN PERI-URBAN NEIGHBOURHOODS OF OWERRI MUNICIPALITY

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ABSTRACT

Basic housing infrastructure influences the comfort of several residents. There are, however, indications that the residents in several urban housing estates in Nigeria are dissatisfied with their housing infrastructures and maintenance. Therefore, this study focuses on evaluating the relationship between the quality of housing infrastructure and the decision of occupants on where to live. This study involved the application of a quantitative approach with the aid of a structured questionnaire to collect data from residents. The survey was conducted in six selected neighbourhoods of Owerri Municipal area with the occupants as respondents (n=399). Moreover, the chi-square test of independence was applied to determine the relationship between the quality of housing infrastructure and the decision to live in either the urban areas or move to the peripheries. The result (χ^2 (39) = 920.41, p < .001) showed a significant association and this implies potential occupants should be consulted more in the conceptualisation and execution of housing projects to ensure their expectations are met.

Keywords: Housing infrastructure; Project stakeholder; Residents; Urban; Urbanization

1. INTRODUCTION

Housing is a necessity of mankind, due to its significant effect on every other activity (Coker, Awokola, Olomolaiye, & Booth, 2007). This is the reason the provision of adequate housing is a precondition to achieving stable communities and ensuring social inclusion (Adeoye, 2016; Oladapo, 2006). However, the increase in population in the area due to migration is exerting pressure on the available housing and infrastructure (Ajala, 2005; Aluko, 2010). It creates accommodation challenges and forces several people to live in low-quality and overcrowded dwellings (Meng, Hall, & Roberts, 2006). Housing quality symbolizes the meanings and values ascribed to variables such as 'comfort' or 'quality of life' provided by different dwelling types, lifestyles, and residents' preferences and expectations (Garg, Dhagat, & Shrivastava, 2014). According to Krieger and Higgins (2002), it does not only refer to the physical condition but also the quality of the social and physical environment the house is located. It is important to note that housing quality can be influenced by the design (Mitchell, Zhang, Sigsgaard, Jantunen, Lioy, Samson, & Karol, 2007), utilities, and the basic services provided (Meng et al., 2006).

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It was, however, reported from empirical studies that housing stocks with the required quality are difficult to provide (Odekoya & Johnson, 2017) despite the fact that the comfort of an occupant in a house has been confirmed to be influenced by the availability of basic infrastructure (AbdulAzeez, Owoicho, & Dahiru, 2015). Moreover, several studies showed that occupants are dissatisfied with poor or substandard infrastructures of urban housing estates and their maintenance in Nigeria (Anofojie, & Kadiri, 2014; Ibem, Aduwo, & Ayo-Vaughan, 2015; Ogunsanya, Fanu, & Oladipo, 2016; Okoye, 2014).

The term "housing infrastructure" is operationalised in this study as the services, facilities, equipment, and devices such as sewage, sanitation, roads, electricity, drainage, waste disposal, and other public transportation systems needed or desired for the physical, mental, health, and social well-being of families and individuals. Meanwhile, urban growth is contextualized as a spatial and demographic process associated with the increased importance of towns and cities in relation to population concentration in the economy and society. It is different from urbanization which indicates the complex change in lifestyles due to the influence of a city on its society (Clark, 2014). Another factor considered in this study is housing affordability. It is explained as the cost of housing services and shelter for both the renters and owner-occupants which is usually influenced by the disposable income of the individual or household (Bieri, 2014). A relationship has been established between the design, functions and amenities, cost of housing, and the income flow of prospective consumers (Onyike, 2007). Moreover, housing has been described as a need competing with fixed household incomes (Ibem *et al.*, 2015; Nnametu & Emoh, 2020). This implies adequate housing in the city requires a huge part of the income earned by occupants, thereby, limiting their chances of attending to other competing needs. This, according to Onyike (2007), can be due to scarcity of accommodation not necessarily due to rural-urban drift but the ineffective implementation of housing programs by the government.

Population growth and urbanization have caused a continuous increase in the demand for housing in the city, but the supply is more or less static. Therefore, it is necessary to study the social issues and trends associated with urban-semi-urban (urban periphery) migration to ensure new housing projects are acceptable to residents (Sarkissian, Walton, Kerr, Hazebroek, Ludher, Shore, Hazebroek, & Humphreys, 2004). This is expected to provide insight into the movement of residents from urban centres to peripheries to serve as a guide for the future development of housing estate projects in Nigeria.

2. LITERATURE STUDY

Urban periphery or peri-urban area has been reported in previous studies not to be a suburb but a hybrid of urban and rural areas which is usually beyond administrative boundaries (Camagni, 1994; Cattivelli, 2021; Wandl & Magoni, 2017). Its landscape encompasses highly fragmented productive and residential agglomerations associated with more or less dense infrastructural networks and separated by empty agricultural or residual spaces (Wandl & Magoni, 2017). Moreover, Cattivelli (2021) stated that the urban periphery structure is characterized by low population density and is normally preferred by new inhabitants such as pensioners, families, and migrants based on housing-family property. The area is economically integrated into neighbouring urban areas (Aksoylu, 2015) and is considered important to relocated firms and interlinkages with infrastructural hubs.

The consequence of an urban-rural pull in Nigeria is that an increasing proportion of the population now lives in urban areas (Onibokun & Faniran, 1995; United Nations, 2018), either in public or privately owned houses. Moreover, urbanization was viewed as an agglomeration, within a particular spot, of people in a relatively large number (Olotuah, 2005) and its consequential impact has been identified to include unemployment, urban congestion, and

environmental degradation among others (Muhammed, Sabiu, & Khalil, 2015). The upsurge and influx of people continually into the urban cities also have a negative effect on the available infrastructure and basic facilities. Aluko (2010) argued that the pressure of urbanization has affected the dignity, social cohesion, and administrative efficiency of several urban cities in Nigeria. This is evident in the occurrence of environmental pollution, general urban decay, and an overstretch of existing limited facilities (Aluko, 2010; Duru & Anyawu, 2014). Furthermore, the increase in urban population has created insecure and overcrowded residential settlements characterised by poor structural quality, inadequate access to safe water, lack of sanitation and others (UN-HABITAT, 2003). It was further suggested that several housing projects developed in the country failed to adequately consider and provide the necessary infrastructure. It is also important to note that the reasons for the urban transition in the peri-urban landscape include socio-demography, linkages to the metropolises, availability of basic services, availability and affordability of housing for the low-income migrants as well as the state government policy on land use (Mabogunje, 2002; Okeke, 2016). Moreover, Emankhu and Ubangari (2017) noted that peripheral area is not just the transition of land from its rural state to urban use but also involves complex processes such as a change in land ownership pattern, land transfer processes, regulatory measures and their enforcement. This aligns with the views expressed in Calderia (2016) that peripheral urbanization does not necessarily mean expansion to the periphery but rather a way to produce space in other places.

The migration of people to peripheral areas can be argued to be instrumental to the decongestion of urban centres, an extension of development to the outskirts such as rural communities, and the reduction of high congestion in the urban core. It is, however, important to state that these areas have the potential to become inaccessible to the poorest residents due to their improvement over time (Calderia, 2016). The achievement of sustainable and properly managed urban growth in Nigeria requires an effective housing policy framework capable of addressing the tripartite forces of population increase, spontaneous increase in the size of cities, and the acute shortage of habitable dwelling units (Jiboye, 2011). Furthermore, Okeke (2016) suggested that sustainable development can be achieved within urban peripheries through the application of innovative strategies for urban development with due consideration for the socio-economic and cultural setting of the target population. Farrell (2018) also argued the need for more strategic management of urban transition considering its greater speed and magnitude compared to the capacity of governments to provide the necessary housing, infrastructure, and amenities to cope with the growing urban population. Moreover, Sarkissian *et al*. (2004), indicated the need to study the social issues and trends associated with urban-semi-urban or urban periphery migration to ensure new housing projects cause minimal social or environmental problems and are acceptable to residents.

This can be achieved by applying proven project management principles in the conceptualization, planning, and execution of housing projects. Previous studies showed a significant relationship between project failure and the management strategies applied by the stakeholders (Oguzie, Nwakanma, Ogbonna, & Udunwa, 2021). Moreover, Freeman (2010) defined a stakeholder as any group, or individual, with the ability to influence or be influenced by the outcomes of project objectives. This means the occupants of housing estates are major stakeholders. It has also been stated that the involvement of stakeholders in project execution has the ability to increase the effectiveness of project outcomes (Olander & Landin, 2005; Yang, Huang, & Wu, 2011). Furthermore, ensuring the stakeholders are satisfied with project outcomes is a critical aspect of project management as indicated in previous studies (Baccarini, 1999; Chan & Chan, 2004; Lim & Mohammad, 1999).

3. METHODS

3.1 Study Area

This study focuses on Owerri Municipal area located within latitudes 4° 23′ N and 7° 15′ N and longitudes 6° 50′E and 7° 25′E as indicated in Figure 1. The area covers a landmass of 104 km^2 (40.2 sq miles) and serves as the administrative capital of Imo State with a projected population of 908,109 people based on a 4.07% growth rate (World Population Review). The city is characterized by high population density, increasing population growth, high immigration, high costs and value of developed and undeveloped properties, as well as high income and employment disparities. In Owerri, the housing problems such as the intensity and complexity in the urban centres are generally more severe and profound than in rural areas due to rural-urban drift (Nnametu & Emoh, 2020). Moreover, the city has flat land, a maximum temperature range of 33.4°C and minimum of 21.2°C, and the highest recorded rainfall of 19mm (AC-Chukwuocha, Uchechukwu, Chizoba, & Nnedinma, 2016) which explains the flooding tendencies whenever there is a heavy downpour. The inhabitants of the urban areas are predominantly civil servants, traders, artisans, and native farmers. Furthermore, the economy of Owerri is sustained through commercial, financial, industrial production and services, undertaken by the formal and informal sectors. The formal sector is dominated by the services and manufacturing sub-sectors while the informal sector has been thriving due to the indigenous involuntary survival response of the city's residents to urban poverty and unemployment. Owerri was selected as the study area because it houses about 85% of both Federal and state tertiary institutions including universities, polytechnics, and colleges as the administrative capital. Therefore, there is a high concentration of public and private funded housing developments initiated to solve the lingering problem of housing demand.

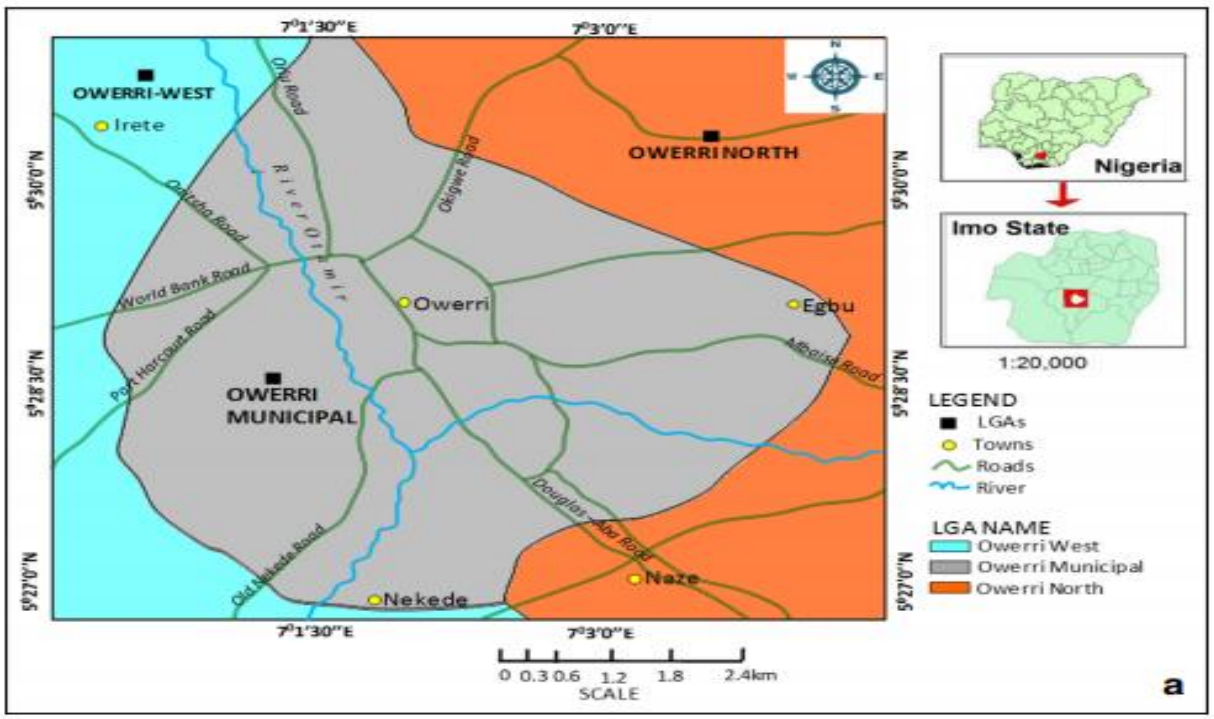

Figure 1 Location of Owerri Municipal. (Source: Ibe et al. (2018))

3.2 Data Collection and Analysis

This study utilised quantitative data collected over three months using a structured questionnaire divided into different sections which include sex, marital status, age, occupation and qualification

of respondents, quality of infrastructure, building design and condition, materials and elements, and social problems faced in the central and peripheral areas of Owerri. A total of 399 respondents were randomly sampled through a face-to-face interview. This sampling approach was employed because it allows the interviewer to clarify questions, probe responses, and assess respondent fatigue (Bowers, 2008). Moreover, the survey was conducted in six selected neighbourhoods which include Tetlow, Douglas, Royce, Obinze, Egbu, and Egbada in Owerri Municipal area. It is important to restate that the focus of this study is to determine the relationship between the quality of housing infrastructure and the decision of occupants in selecting a residence area. The objective is to ascertain the perception of residents on available infrastructure and services, and how this influences the choice of where they reside. This was statistically analysed through the following hypotheses:

H_0: there is no association between the decision to live in an urban or peripheral area and the quality of housing infrastructure

H_1: there is an association between the decision to live in an urban or peripheral area and the quality of housing infrastructure

Descriptive statistics were used to analyse the occupant's responses while the Chi-Square Test of Independence was employed to determine the association between the decision to live in urban or peripheral areas and the quality of housing infrastructure using SPSS statistical tools. The decision rule is that the null hypothesis is rejected when the *p*-value is less than the 0.5 significance level (α).

4. RESULTS AND DISCUSSION

4.1. Socio-Demographic Profile of the Respondents

A total of three hundred and thirty (330) valid responses were received out of the 399 questionnaires administered and this indicates an 82.7% response rate. Moreover, the socio-demographic profile of the respondents presented in the following Table 1 showed that 41.8% were male and the remaining 58.2% were female.

Table 1 Socio-Demographic Profile of Respondents

Variable	Frequency	Per cent	Valid Percent	Cumulative Percent
Gender				
Male	138	41.8	41.8	41.8
Female	192	58.2	58.2	100.0
Total	330	100.0	100.0	
Age Range				
18-30	52	15.8	15.8	15.8
31-40	92	27.9	27.9	43.6
41-50	68	20.6	20.6	64.2
51-60	118	35.8	35.8	100.0
Total	330	100.0	100.0	
Marital Status				
Single	64	19.4	19.4	19.4
Married	238	72.1	72.1	91.5
Separated/Divorced	28	8.5	8.5	100.0
Total	330	100.0	100.0	

The higher number of female respondents is possibly due to the fact that more women were at home when the questionnaires were administered while the men had gone to work. It was also discovered that 52 (15.8%) were in the 18-30 years age range, 92 (27.9%) in the 31-40 years range, 68 (20.6%) in the 41-50 years range, and the highest, 118 (35.8%), in the 51-60 years range. This age distribution mirrors the realities of the labour market. Furthermore, the majority, 72.1%, were married, 19.4% single, and 8.5% either divorced or separated.

The respondents were segregated according to their marital status and age to determine the status of the relocated occupants as shown in Table 2. The results showed that a higher number of married respondents either live in or plan to relocate to the periphery compared to both the single and separated/divorced. More of the single respondents specified they were not residents at the periphery. A similar pattern was also observed for respondents between the 31 and 60 age range that are either residing at or planning to relocate to the periphery.

Table 2 Marital Status and Age of Respondents living at the periphery

Periphery resident	Marital Status			Age			
	Single	Married	Separated/Divorced	18-30	31-40	41-50	51-60
Yes	4	92	27	3	33	24	63
No	21	4	1	6	7	2	11
Will	39	142	0	43	52	42	44
	64	238	28	52	92	68	118

Table 3 distributes the respondents according to their place of residence and it was discovered that 37.3% (123) live at the periphery while a cumulative 62.7% (207) live in the urban area out of which 87.4% have plans to relocate to the periphery while the remaining 12.6% do not intend to move.

Table 3 Distribution of Respondents according to Location of Residence

Location of Residence	Frequency	Per cent	Valid Percent	Cumulative Percent
Live at Periphery	123	37.3	37.3	37.3
Will Not Relocate to Periphery	26	7.9	7.9	45.2
Will Relocate to Periphery	181	54.8	54.8	100.0
Total	330	100.0	100.0	

4.2. Condition of Public Utilities

The concept of housing is beyond the mere provision of a shelter, it encompasses social services and utilities usually combined to make a community or neighbourhood liveable. Table 4 presents the conditions of the public utilities in the study area and it was discovered that the public infrastructures at the periphery are more efficient and effective than those in the central part of Owerri. This implies the availability of public utilities and services such as water, power supply, drainage systems, condition of the street, and waste disposal services influence the decision on the selection of the place to live. Moreover, the results indicated that the residents in the peripheral area have better access to potable water sources and a steady power supply. This further shows that the residents of the peripheral areas have better service provisions than those in the central areas as evidenced by the presence of good waste disposal methods, drainage systems, as well as street conditions.

Table 4 Condition of public utilities

Indicator	Central area		Peripheral area	
	Number of responses	Share of total responses (%)	Number of responses	Share of total responses (%)
Water supply source				
Pipe Bore Water from Central Place	29	8.79	8	2.42
Pipe Bore Water from Near Compound	99	30.00	14	4.24
Personal Well or Borehole	50	15.15	102	30.91
Vendors	20	6.06	8	2.42
Power supply				
Not available	49	14.85	6	1.82
Available but not stable	149	45.15	110	33.33
Available and stable	0	0	16	4.85
Waste collection				
Service provided by the government agency	39	11.82	26	7.88
Service provided by a contractor	97	29.39	20	6.06
Waste disposed of in the dung pit	15	4.55	8	2.42
Waste disposed of by burning	47	14.24	78	23.64
Drainage system				
The drainage system is very poor	20	6.06	0	0
The drainage system is poor	68	20.61	15	4.55
The drainage system is fair	62	18.79	41	12.42
The drainage system is good	48	14.55	65	19.7
The drainage system is very good	0	0	15	4.55
Condition of street				
Tarred and in good condition	59	17.88	46	13.94
Tarred but in bad condition	75	22.73	20	6.06
Adjacent street is not tarred	49	14.85	27	8.18
There is no adjacent street	15	4.55	39	11.82
Total	198		132	

Several residents in the central part of the town do not have parking spaces for vehicles inside their compounds with most observed to be parking along the street as indicated in Figure 2. This affects the environment and health conditions of the area. However, the periphery areas have different situations due to the availability and provision of parking spaces in the residents' yards.

Figure 2 Street parking in Central Areas of Owerri Municipal

4.3. Ownership and Physical Conditions and Quality of Houses

Table 5 shows there is a higher number of blocks of flats in the central area than in the periphery. This suggests that there are more tenants than homeowners in the central area and this possibly explains the reason several respondents said they would be moving to the peripheries soon, perhaps, when their houses are ready. Moreover, it was discovered that more people in the peripheries live in duplexes or detached bungalows designed and built specifically to satisfy their needs. This suggests that more homeowners than tenants live in the peripheral areas and this ownership status can also be the reason the houses are maintained better than those in the central areas. Furthermore, the poor power situation in the central areas leads to the regular use of generators which subsequently causes a higher carbon monoxide gas pollution and suffocation due to reduced oxygen availability.

Table 5 Type, ownership, and physical condition of housing units

Indicator	Central area		Peripheral area	
	Number of responses	Share of total responses (%)	Number of responses	Share of total responses (%)
Type of house				
Joint bungalow	19	5.76	12	3.64
Block of Flats	131	39.70	27	8.18
Self-contained	21	6.36	7	2.12
Detached bungalow or Duplex	27	8.18	86	26.06
Ownership of house				
Own House	29	8.79	88	26.67
Rented House	154	46.67	44	13.33
Squatting	15	4.55	0	0.00
Condition of house				
Good condition	40	12.12	113	34.24
Deteriorated	88	26.67	12	3.64
Dilapidated	70	21.21	7	2.12

The perception of the respondents about the quality of building materials used in their houses was analysed and the results are presented in Table 6. It was discovered that the quality of materials and elements used in constructing the houses at the peripherals was better than those used in the central areas. For instance, a total of 113 (34.24%) peripheral area respondents out of 330 felt the materials and elements used ranged from good to very good quality while only 49 (14.85%) respondents in the central area had a similar perception. This is believed to have contributed to the decision to relocate to the peripheries for a better serene environment with quality houses. The observation is in line with the findings of Meng et al. (2006) that residents assess housing quality based on the construction materials employed and this, in turn, influences the acceptability.

Table 6 Perception of Respondents about Quality of Building Materials used

Indicator	Central area		Peripheral area	
	Number of responses	Share of total responses (%)	Number of responses	Share of total responses (%)
Very poor	13	3.94	2	0.61
Poor	55	16.67	5	1.52
Fair	81	24.55	12	3.64
Good	46	13.94	36	10.91
Very good	3	0.91	77	23.33
Total	198		132	

4.4. Housing Environment and Social Problem

Another factor likely influencing the choice of residence is the level of social problems encountered and the differences observed between the central and peripheral areas are presented in Table 7. The results showed the existence of social problems in all parts of Owerri municipal but those in the central areas have greater experiences of social vices such as robbery, prostitution, kidnapping, and cultism than those at the periphery.

Table 7 Social Problems faced by Respondents

Indicator	Central area		Peripheral area	
	Number of responses	Share of total responses (%)	Number of responses	Share of total responses (%)
Robbery Attacks	69	20.91	11	3.33
Prostitution	19	5.76	0	0.00
Kidnapping	6	1.82	0	0.00
Cultism	51	15.45	0	0.00
None	53	16.06	121	36.67
Total	198		132	

4.5. Decision to Live in Urban Core or peripheral area and the Quality of Housing Infrastructure

The result of the hypothesis test conducted to determine the association between the decision to live in urban or peripheral areas and the quality of housing infrastructure is presented in Table 8. It was discovered that some cells have less than 5 expected cell counts but this does not affect the result because they are not more than 20% as indicated in existing works in statistical analysis (Conover, 1980; Conover, 1999; Yates, Moore, & Mccabe, 1999). Moreover, the Chi-Square test of independence is χ^2 (39) = 920.41, $p < .001$ showed that there is an association between the decision to live in the urban or peripheral area and the quality of housing infrastructure. This is indicated by the p-value (0.000) which is less than the 0.05 significance level, thereby, leading to the rejection of the null hypothesis and acceptance of the alternate hypothesis.

Table 8 Result of Chi-square test of Independence

Test	Statistic	Df	P-Value
Chi-Square	920.41	39	0.0000

2 cell(s) with expected cell counts less than 5

These findings are in line with conclusions drawn from earlier studies on the non-provision of housing stocks with the required quality of infrastructure (Odekoya & Johnson, 2017). They also reinforce the observation from existing studies that the comfort of an occupant is influenced by the availability of basic housing infrastructure (AbdulAzeez *et al*., 2015). Moreover, it has been previously reported that occupiers of houses are dissatisfied with poor or substandard housing infrastructure provisions and maintenance in several urban housing estates in Nigeria (Anofojie *et al*., 2014; Ibem *et al*., 2015; Ogunsanya *et al*., 2016; Okoye, 2014), thereby, leading to the preference to build houses to satisfy their taste at the peripheries of these urban areas. Torrey (2004), however, noted that this migration trend has consequential health, social, and environmental challenges such as prostitution, squalor settlements, as well as the number of people engaged in odd and menial jobs for survival (Nweke, 2019).

5. CONCLUSION

This study was conducted to ascertain the association, if any, between the decision to live in urban or peripheral areas and the quality of housing infrastructure and the results showed the existence of a significant association. An inference drawn was that the housing units at the peripheries were designed with the active involvement of the occupants and this made it possible to address their needs and tastes. It is, therefore, necessary to engage potential occupants of public housing estates in the design and execution of housing projects to stem undue migration to the peripheries which can lead to an encroachment on the ecology of the area such as the possible reduction in agricultural production. This is important because peripheries are usually green belt zones normally used to boost agricultural production and safeguard the natural environment.

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AN OVERVIEW OF THE SIGNIFICANCE AND APPLICATION OF CONSTRUCTABILITY IN VALUE ENGINEERING

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ABSTRACT

Value Engineering (VE) and constructability are not distinct; instead, they are complementary work processes that may be used as vital elements in achieving total quality. Constructability is a value management (VM) tool developed as an attempt to integrate design and construction activities. VE is often implemented when there is a limited chance to influence the cost and time of the project effectively. Thus, project contractors and owners conduct VE analysis before construction by applying the constructability process. The activities of these two processes somehow complement each other in achieving their goals. Considering the output of existing VE approaches, it seems that despite the significance of constructability, it does not have an appropriate significance in VE projects. This study aims to evaluate the importance of constructability in VE and provide some suggestions for facilitating and improving it with VE. A type of systematic review in the related literature and conducted pattern coding called overview was utilized to obtain the study's aim. The research found that a large part of the proposed VE solutions that cover the principles and concepts of constructability focused on the pre-study and the main study phases of VE and the management subgroup. Significant areas related to the supplementary studies phase or environmental solutions, including cultural and legal issues, have been neglected. Therefore, addressing them provides an appropriate context to improve constructability by using the VE process.

Keywords: Value Engineering (VE); Constructability; Systematic review, Construction Industry

1. INTRODUCTION

The distinction between design and construction phases and the increasing growth of these issues lead the construction industry to implement Value Engineering (VE) services and consider constructability issues. VE provides a tool to reduce project lifecycle costs, while constructability services benefit constructive participation during the planning and design stages. Although VE may save money, a project cannot be succeeded just by relying on it. Integrating the process with all the stakeholders is the best way to bring together a qualified team, collaboration, design, and construction, as well as implement constructability and value improvement. Further, constructability that uses knowledgeable and experienced professionals to make better decisions can maximize the profit for the owner because it influences the whole project. It is so mainly when the constructability is done at the early stages of planning and design before creating a particular scope.

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Nowadays, the industry's knowledge and experience can be involved with design decisions to influence the project output significantly (Al-Fadhli, 2020). Unfortunately, while some concepts of constructability are considered in implementing the usual VE process, they are often conducted after essential design decisions have been made. Not only is this too late, but it can also no longer make changes that maximize profits. Probably, it reinforces the notion that, at this time, it is just a critique of the designer or favor to the owner. Under such conditions, VE implementation may be too late and useless.

The significance of constructability in the VE implementation was first mentioned four decades ago in the Texas Highway guide by Hugo et al. (1990). However, the issue was still not taken seriously until 1994, when the impact of using VE and constructability concepts to enhance total quality management was evaluated by Russell et al. (1994). They concluded that VE and constructability are complementary processes that may be used as vital elements in achieving total quality.

Despite the abundance of existing research in implementing VE and constructability techniques and how the plans and models were developed, some question remains unanswered. For instance, scholars are still wondering how much the literature addresses these two concepts and how much the VE solutions focus on constructability. Can the place of constructability be improved with the help of VE? The answer to these questions will determine the current state of focus on constructability issues and their position in VE implementation. It can also improve awareness of the current situation and the extent to which the mission of VE has improved constructability. Moreover, how much the proposed value solutions overlap with the principles and concepts of constructability provides suggestions regarding strengthening these areas can also be determined. To answer these questions, this research begins by introducing constructability and VE. Following that, using the overview method, it analyzes and evaluates the current focus of VE solutions on constructability, recent improvements, and neglected issues in the existing literature.

2. LITERATURE STUDY

2.1. Constructability

Increased competition and the introduction of product concepts in the construction industry have triggered the industry to become very specialized. Such specialization in the construction industry has separated design and construction activities. These changes consequently bring designers gradually to move away from the construction process. It has been observed in many cases that their plans show a less understanding of the construction process. This lack of comprehension due to the designers' ignorance and inexperience has often led to increased construction costs.

Sometimes, it leads to unconstructive designs (Russell, Swiggum, et al., 1994). Constructability is one of the concepts that help develop integrated designs. The concept of constructability, which first appeared in the United States as buildability and later in the United Kingdom in the late 1970s, refers to how productivity and quality in the construction industry can be improved by linking the design and construction sectors to each other (Trigunarsyah, 2007). Accordingly, when the project ideas are formed before construction, the most significant constructability issues should be considered in the designs (Mathern, 2019). However, ignoring constructability by designers and contractors has become almost commonplace during the project phases. Thus, the obstacles to implementing these activities are essential for achieving the projects' general goals that must be addressed in developed and developing countries (Saghatforoush et al., 2009). Some of the advantages of constructability include: 1) timely completion and following the initial planning; in some cases, the projects can be accomplished earlier than scheduled, 2) saving project costs, 3) reducing costs due to design changes, 4) improving the quality of the project, 5)

achieving an acceptable level of productivity, 6) improving team performance, 7) reducing adverse risks of the project, remarkably, those related to unpredicted problems, 8) improving communication between key stakeholders, and 9) increasing the satisfaction of customers and project stakeholders (Eldin, 1999; Elgohary et al., 2003; Francis et al., 1999; Jadidoleslami et al., 2018; Jergeas & Put, 2001; Pheng & Abeyegoonasekera, 2001; Trigunarsyah, 2004). In short, constructability tries to minimize the gap between what the designers do and what the contractors implement on the project site.

Based on the reports of the construction phase and results, implementing construction criteria at all project stages requires much information. However, in the initial phase of designing construction projects, there is a possibility of reducing the adverse effects and increasing the positive impacts of applying the concepts of constructability. One of the strategies is to use performance-based requirements. Indeed, it requires design processes and methods that support informed design selections (Mathern, 2019; Mendelsohn, 1997). The Construction Industry Institute of Australia (CIIA), a leading institution that studies constructability in Australia, has presented 12 principles in a 25-to-30-year effort. The CIIA has considered the most appropriate time for applying these principles in the project lifecycle. These principles are suitable for the objectives of this study, covering:

1. Integration: constructability should be implemented in the project's design phase in an integrated form.
2. Knowledge of construction: project design should include simultaneous application of knowledge and experience.
3. Team skills: the composition of the project team and their capabilities, experiences, and skills should be compatible with the project definition.
4. Common goals: defining and understanding common goals will increase the project's level of completion.
5. Available resources: applied technologies in the design sector should be compatible with the existing resources and capabilities.
6. External factors: these factors affect the project’s cost and time.
7. Plan: the detailed project plan should be implementable, and the project team should be committed to its implementation.
8. Construction methodology: the construction method should be thoroughly considered in designing the project.
9. Accessibility: considering the accessibility of the construction phase in the design phase will increase the project’s level of completion.
10. Specifications: constructability should be considered in developing and expanding the project specifications.
11. Technology: using innovations and new methods and technologies will improve the project implementation.
12. Feedback: it is helpful to evaluate and analyze the project after its construction by an experienced team to improve the constructability of similar projects in the future.

The principles of constructability and their role in the project lifecycle are presented in Table 1.

Table 1 The principles of constructability (CIIA, 1993)

PROJECT LIFE					PRINCIPLES OF CONSTRUCTABILITY	
After construction	Construction	Design development		Planning / Feasibility		
		Detailed design	Conceptual design			
MR	MR	MR	VR	VR	Integration	P1
IR	MR	MR	VR	MR	Knowledge of construction	P2
IR	IR	VR	VR	R	Team skills	P3
MR	IR	IR	VR	VR	Common goals	P4
IR	IR	R	R	VR	Available resources	P5
IR	IR	MR	R	VR	External factors	P6
IR	R	R	VR	MR	Program	P7
IR	IR	VR	VR	MR	Construction methodology	P8
IR	R	VR	VR	IR	accessibility	P9
IR	IR	VR	IR	IR	Specifications	P10
IR	VR	IR	IR	IR	Technology	P11
VR	IR	IR	IR	IR	Feedback	P12
LEGEND: VERY RELEVANT (VR) RELEVANT (R) MEDIUM RELEVANT (MR) USUALLY IRRELEVANT (IR)						

As provided in Table 1, constructability is not limited to the design phase. Instead, it should be processed throughout the project lifecycle. As the project progresses, the impact of design errors on the overall cost of the project increases. Therefore, to achieve a higher impact, it is better to use constructability in the project initial phases, such as the design phase (Zolfagharian et al., 2012).

Nima et al. (2001) proposed 23 concepts to improve and facilitate constructability at different stages of the project lifecycle. In addition to the 12 constructability principles, these concepts have been considered a basis for evaluating the significance of constructability in VE and other relevant review studies, shown in more detail in Table 2.

Table 2 The concepts of facilitating constructability in the project lifecycle (Nima et al., 2001)

The concepts of improving constructability in the conceptual planning phase	
C1	The constructability plan of the project should be discussed and documented through the participation of all project team members in the execution plan.
C2	A project team consisting of the owner representatives, the engineer, and the contractor, should be formed and maintained to address the construction issue from the beginning to the end of the project.
C3	Knowledgeable and experienced people in the construction field should have access to the project's initial planning to avoid interferences and conflicts between designs and construction phases.
C4	Construction methods should be considered in selecting the type and number of contracts required for the project implementation.
C5	The main construction project schedule should be implementable in the construction and should be determined as soon as possible

C6	To conduct field operations quickly and efficiently, the main construction methods should be reviewed and analyzed as soon as possible to guide the design according to these methods. It can include recovery and improvement methods as well as sustainable planning.
C7	The site layout should be carefully considered to ensure that construction, operation, and maintenance are performed efficiently. In addition, it aims to avoid interferences between activities performed during these steps
The concepts of improving constructability in the preparation and implementation phase	
C8	Design and preparation plans should be compatible with the construction sequence. Therefore, the implementation plan should be addressed before the design and preparation.
C9	Advanced information technologies are essential for any field, including the construction industry. Therefore, using those technologies overcomes the problem of assigning specialized roles in this field and strengthens the structure.
C10	The designs should be configured by simplifying and reviewing the design by qualified personnel of construction and implementation. By so doing, the construction can be more efficient.
C11	Project elements should be standardized to the extent that they never adversely affect the project cost.
C12	Technical specifications of the project should be simplified and configured to achieve efficient construction without reducing the performance level or efficiency of the project
C13	The modulation and pre-installation of the project elements should be considered and carefully studied. Transportation installation, prefabricated modularity, and design should be among the desired options to facilitate construction.
C14	Project design should consider the access to human resources, materials, and equipment required at the site.
C15	The design should strive to facilitate construction in unfavorable weather conditions. They should plan for project construction in favorable weather conditions. Under changing climate conditions, the designer should increase the project elements used in the workshops in the form of prefabricated structures
The concepts of improving constructability in the operation phase	
C16	The sequence of field tasks should be adjusted to minimize the damage to the efficiency of some project elements. Additionally, the adjustment can reduce the need for scaffolding, the applied format, or the density of human resources, materials, and equipment
C17	Innovation in temporary construction materials or systems and innovative implementation of existing construction materials or systems that are not limited by design maps and technical specifications will improve the constructability.
C18	Innovation in new methods of using tools and technology, modification of existing tools and technologies, or introduction of new tools and technologies that will reduce labor intensity, and increase mobility, safety, or access, will improve constructability in the implementation phase.
C19	Introducing innovative methods to use existing equipment or modifying existing equipment to increase productivity will improve constructability.
C20	Encouraging the builders to use prefabrication to increase productivity, reduce scaffolding, and improve the project’s constructability under unfavorable weather conditions.
C21	Encouraging builders to innovate using temporary facilities will increase constructability.
C22	The good contractors' list should be documented based on quality and time. By so doing, contracts for future construction work should be determined not only based on low bids but also on other features of the project, such as quality and time.
C23	Evaluation, documentation, and feedback on issues related to constructability concepts should be maintained throughout the project to be used as the lessons learned in future projects.

2.2. Value Engineering

The Society of American Value Engineers (SAVE) defines VE as a set of systematic and applied techniques used to evaluate the function of a product or service. Further, the method ensures that the function is used at a minimum cost. The main difference between VE and other project optimization tools is in solving the problem and focusing on teamwork along with cost-benefit analysis of possible solutions. VE is about achieving the specified functions, at the lowest cost (or total cost of project lifecycle), without compromising quality, and with the reliability of performance or delivery (Pulaski et al., 2006). In large-scale projects, VE studies are usually conducted at 30 to 90 percent of the design stage. In such studies, technical requirements are considered, and significant savings are achieved in most projects. However, there are cases in which some reliable VE recommendations are not accepted. One of the reasons for losing such opportunities is that the proposed changes recommend modifying the underlying criteria of the project. From the employers' view, such modifications are considered a violation of the underlying criteria. In some cases, key decision makers may consider the significant changes at this level as an opportunity to unravel the ambiguities of the project. To provide logical and defensible answers to these questions and reduce the potential of losing such opportunities, a value planning approach has been considered to help the project clients to take maximum advantage of applying VE (Hammersley, 2002)

Systematic VE is reflected in the work plan, an applied formula that guides the team in the VE implementation throughout the process. VE's work plan is aligned with the step-by-step and creative problem-solving framework. There are various standard work plans for VE according to the country's laws or the executive organization. SAVE proposed a work plan that many researchers have used as the basis of their study. It consists of three main stages: pre-study, main study, and supplementary study (Al-Yafei et al., 2017). The stages and steps of the work plan are put into several classifications, as presented in Figure 1.

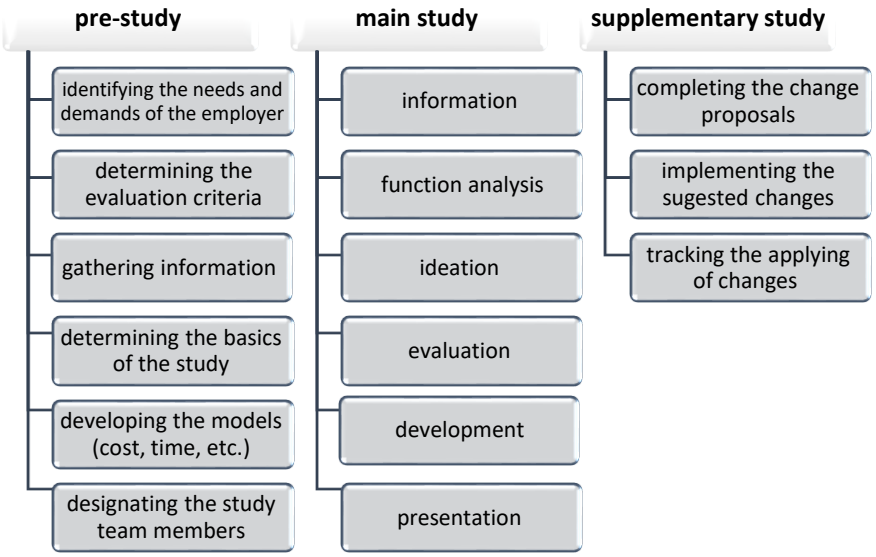

Figure 1 VE Work plan (Al-Yafei et al., 2017)

Despite a slight difference, most existing literature agrees with this classification. Sometimes, two or more stages is presented in one step. These stages focus primarily on three stages, that incluwhich

1. Pre-study stage: The activities done at this stage should fulfill the prerequisites and requirements of the main study phase, which involve identifying the needs and demands of the employer/customer, determining the evaluation criteria, gathering specific information, defining the basics of the study, developing the models, designating the study team members, and planning for holding study sessions. Furthermore, the activities also include collecting and compiling information as a pre-study report for the information phase in the main workshop.
2. The main study stage includes the main steps of implementing value methodology. The most crucial stage of this classification is the main workshop, including six-phases information, function analysis, creativity (ideation), evaluation (judgment), development, and presentation.
3. Supplementary study stage: The purpose of the supplemental study is to ensure the implementation and application of the recommended changes at the end of the value study. As long as the ideas of the study are not implemented, the study will not be practical. The most important task of the experts of the VE team or other experts approved by the management is to complete the changes recommended by the VE team. Moreover, they need to develop, complete, and present an implementable plan. It is one of the reasons why one of the project managers should be a member of the value team. While the value team leader may track the implementation progress, the project consultant (designer or planner) is responsible for the project implementation.

2.3. The Position of Constructability and Value Engineering in the Project Lifecycle

VE can be implemented at any project lifecycle stage to significantly impact the project results. However, it is evident that if it is implemented at the early stages of the project, less effort will be needed at the later stages (Al-Yafei et al., 2017). During the construction phase, value analysis may be performed by the designers or the contractors. As the project progresses, it is impossible to change the technical specifications without making changes to the project cost. The number and periods of the VE analysis are determined by the project's technical and financial conditions. In costly and complex projects, some supplementary intermediate studies may be conducted.

Meanwhile, small and uncomplicated projects may only require one analysis. The best time to start VE in a project is when the design is completed for approximately 25 to 35 percent, where primary systems have been determined, and the VE suggestions can be implemented based on the schedule without interruption. If the VE workshop is set up at this stage, it will achieve its highest efficiency since all design sections operate under VE supervision. Subsequently, about 60 to 70 percent of the design progress is suitable for performing VE because many details of the design and the selection of suggestions are done. The VE team allows the items to be correctly matched as it is an efficient help to the project team. In other cases, a VE workshop may be needed at the end of the construction phase. It is so when the project requires too much budget or focuses on the final design's effectiveness (Shariatmadar & Astaneh, 2013). Accordingly, due to this fact, there is various time conducting VE analysis or studies during the project lifecycle. Thus, different methods for using these services may be applied depending on the study's time.

Therefore, VE can be done either actively or reactively. The active approach uses VE to gather ideas from the beginning of design. Thus, different design options are considered, and the most cost-effective option is conducted continuously at the design stage. The reactive method gathers cost-effective possibilities by reviewing the design of other project personnel, such as builders and other design engineers. This task is carried out after completing the design or a specific component. Therefore, the reactive approach suggestions must be redesigned to improve the desired areas.

VE and constructability are complementary work processes that may be used as vital elements in achieving total quality. Constructability is a value management tool developed as an attempt to integrate design and construction activities. Figure 3 shows the ideal feedback channels associated with these two approaches in the facility life cycle (Morro, 1991), where VE is a feedback loop that is limited to the design phase, suggesting it to be performed at the early stages of the project to maximize the results. If VE is applied at later stages, it may increase the investment required for implementation and resistance to change (Al-Fadhli, 2020).

As the VE implementation is usually done when there is a limited chance for effective influence on the project cost or time, applying the constructability process allows the contractor or the owner to analyze the VE before the beginning of construction. This issue shows the significance of ongoing feedback or the availability of the lessons learned and experiences. The constructability includes all the feedback loops from the implementation phase shown in Figure 2, where the entry of executive experts at all stages of the facility cycle is desirable. Therefore, studying process constructability is valuable and can be considered a subset of the VE process.

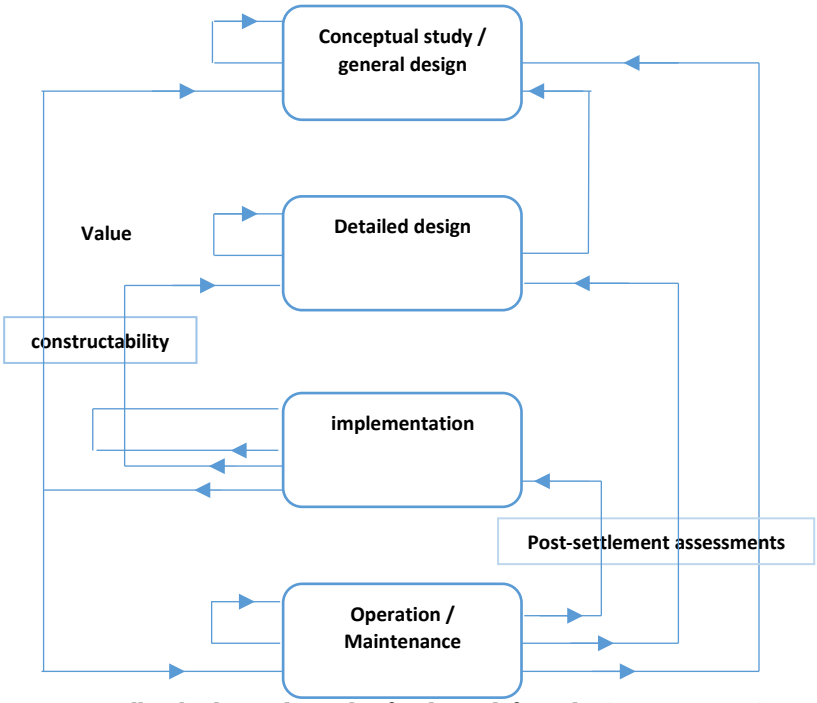

Figure 2 Feedback channels in the facilities lifecycle (Morro, 1991)

3. METHODS

3.1. The Basics of the Overview Method

The first review of research on a particular topic should be carried out as an overview (Higgins & Kanaroglou, 2016). The overview research methodology is appropriate for this study since the aim of this study is to provide a general view of the concepts and principles of constructability in the VE approach. Moreover, it is one of the studies that has not been discussed yet through systematic reviews. An overview is a term for different techniques of presenting a general view of an issue. This review can have various levels of structuring. Some researchers have equated an overview with a qualitative and narrative review. However, it seems more appropriate to consider it a semi-systematic study group (Tsagris & Fragkos, 2016), considering its purpose to review the texts and describe their features. In this method, there is no limitation on database selection. Therefore,

after selecting keywords and search strategy, the approach focuses on selecting articles and studies with a higher combination of keywords. The selection criteria for screening articles are done according to the article's coherence degree with the objectives of this study. The research steps are shown in Figure 3.

Figure 3 The research steps

3.2. The Overview Steps

As this method is close to the narrative review approach, no systematic steps or stages are defined. According to the existing valid articles conducted using this method, the steps of the review are determined as follows (Banerjee & Ghose, 2016; de Bakker et al., 2010; Fischer & Onyango, 2012):

Step 1: Developing the screening criteria for eligible studies

The main research question was about finding the current position of constructability in the VE approach. This research determined some acceptance criteria to select articles, covering:

a. Language of the articles: English
b. Release time: 1990 was selected as the basis of the search limitation, given the start of the constructability concept expansion
c. Type of studies: books, articles, and dissertations published in valid scientific journals or conferences

Step 2: Search for studies

In this study, five databases in English were searched without a time limit. The searched keywords were *"Value Engineering" AND' (Constructability; OR buildability)'.*

Step 3: Selection of studies and data collection

Step three is selecting the appropriate articles. In this step, the articles found in the previous step were evaluated and screened step by step. To achieve this aim, the found papers were reviewed several times, and several of them were deleted. After searching and studying the mentioned databases and evaluating their compliance with the acceptance criteria defined in the first step, some articles related to VE and constructability were found. These articles were found based on the keywords. The details of the search and delete processes are presented in Table 3.

Table 3 The name of databases searched in the present study

Database name	Initial search	After the first screen	After the second screen	After the final screen
Science Direct (Elsevier)	43	22	0	0
Google Scholar	63	41	32	17
ASCE	34	6	6	5

Database name	Initial search	After the first screen	After the second screen	After the final screen
Springer	97	49	27	7
ProQuest	2	2	2	1
Total	239	120	67	30

According to Table 3, the process of selecting articles is as follows:

a. A total of 239 selected articles were reviewed. During this stage, titles unrelated to the research question were removed (119 articles were removed, and 120 remained).
b. Subsequently, the abstracts of the remaining articles were reviewed, and the abstracts unrelated to the research question were removed (53 articles were deleted, and 67 remained).
c. Then, the results of the remaining articles were studied, and the articles that did not answer the research question were removed (37 articles were deleted, while the rest remained).

Finally, 30 articles remained and proceeded to the next step. In qualitative studies, there is a possibility of confirming samples with limited numbers, such as this research. If so, it is emphasized that if the resulting piece is selected following the qualitative and systematic principles, it will cover all the information that the researcher is looking for (Lincoln & Guba, 1984; Tsagris & Fragkos, 2016). The specifications and frequency of the selected articles are presented in Table 4. It includes their release time, type and nature of studies, and research methodology.

Table 4 The name of databases searched in the present study

Year of publication				Type of review studies				The research method of selected articles				
Group	1990-2000	2000-2010	2010-2020	Book	Article	Thesis	Government reports and documents	Case study	Survey	benchmarking	Book	Without mentioning the method
Total	10	8	12	2	25	1	2	8	12	6	2	2

According to Table 4, most studies in this review were conducted from 2010 to 2020. The data indicates the increased awareness of the significance of the place of constructability in value studies in the last decade. Most of these studies were conducted through survey methods. In addition, about 83 percent of them were published in Scientific databases, whereas the rest took the form of books, dissertations, or government reports.

Step 4: Bias risk evaluation in studies

The methodological quality or bias risk evaluation in the preliminary studies is necessary for a systematic review. The first qualitative validation of articles is to ensure the search process described in the previous steps. It means that if the selection of the articles in terms of the searched database were made correctly in the last step, the reviewer could then start extracting and evaluating the information from articles that meet the input criteria. The type of extracted data focused on the purpose of the review. At this stage, the data to be extracted and the data extraction process should be documented. The mentioned process has been observed in this research.

Step 5: Data analysis

In this study, a code was first assigned to all VE solutions. The code that covered the principles and concepts of constructability was screened in joint studies related to the purpose of the research. After that, the code was analyzed.

Step 6: Presenting the results and "summary findings" tables

The analysis results were presented in the format of tables.

Step 7: Results interpretation

In step seven, the details of the review results were interpreted.

4. RESULTS AND DISCUSSION

Citavi 5 software was used for taking notes. Table 5 shows a part of the approach related to this review step.

Table 5 A Part of the extracted codes related to the place of constructability in VE studies

NO.	VE solutions enhancing constructability	Cover-related constructability principles	Cover the concepts of improved constructability	The implementation phase of the proposed solution in VE	Source
1	Knowledge management	P12	C23	Pre-study/data collection	(Al-Fadhli, 2020)
	Strengthen communication between partners, and take advantage of the experience of contractors and subcontractors	P1,P2,P3	C1, C2, C3, C4, C5	Pre-study/data collection	
	Focus on the design phase	P2, P5	C8, C14 ,C21, C22	Main study/function analysis	
	Improve relationships between different parties in the project	P4	C2,1	Pre-study/identifying the needs of the owner	
	Use the suggestions and experience of contractors in practical options	P1, P2, P3	C1, C2, C3, C4, C5	Pre-study/data collection	
2	Risk identification	P6	C7, C8, C10, C15	Main study/function analysis	(Charles et al., 2017)
	Assessing the ability to build a project with the entry of the main stakeholders of the project (including design and construction personnel)	P1, P2, P3	C1, C2, C3, C4, C5	Pre-study/data collection	
	Structural study of design using building information modeling (BIM)	P11	C9, C18	Pre-study/preparation of models	
	Gathering evidence and lessons learned	P12	C23	supplementary studies	
3	Builder interaction between building owner, building designers, and builder	P1	C2	Pre-study/data collection	(Omigbodun, 2001)
	Provide extensive knowledge of the design team in providing appropriate options	P5, P8, P2	C10, C11, C13	Pre-study/data collection	
	Simplification	P5, P8, P2	C10, C11, C13	Main study/function analysis	
	Simultaneous engineering	P1, P2, P3	C1, C2, C3, C4, C5	Pre-study/data collection	
	Assemble a multidisciplinary team at the beginning of the project	P1, P3	C1, C2	Pre-study/Determining team members	
	Conduct audits and reviews	P12	C23	supplementary studies	
	Modular constructions	P8, P9, P10, P11	C13	Main study/development	
	Planning	P7	C1, C5, C8	Pre-study/data collection	

The focus of studies in the project lifecycle was investigated by considering the frequency of extracted codes related to the constructability principles in this step, the resultso of which is shown in Figure 4.

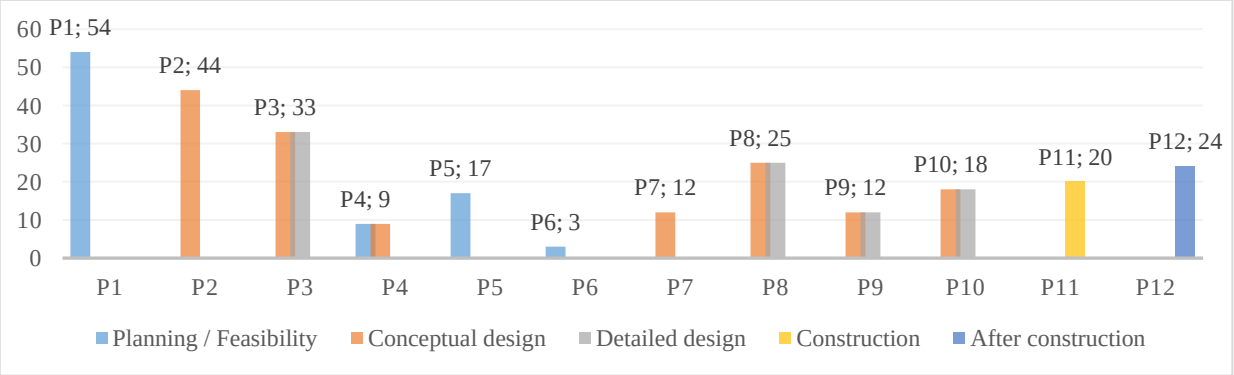

Figure 4 Extracted codes related to the place of constructability in VE studies

As argued earlier, Table 1 reveals that the best time to use the 12 principles of constructability in the project lifecycle varies and is not restricted to one phase. Thus, Figure 5 describes that some principles corresponding to the related phases will cover more than one column. For instance, the P3 principle stated that the best time to use it was both in the conceptual and detailed design phases. Its corresponding column in the diagram covered both phases, hence, the two columns. In contrast, other principles were shown in single columns, such as P1, whose best usage time was only in the planning and feasibility phase, and P2, whose appropriate phase was only in the conceptual design phase. Figure 5 shows the extracted codes related to the concepts of improving constructability, presented separately according to the degree of focus of studies in the project lifecycle.

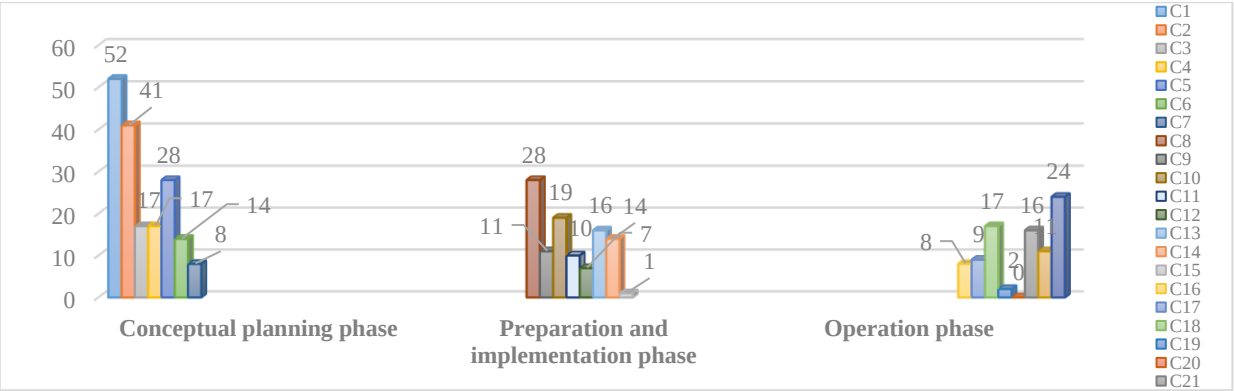

Figure 5 Extracted codes related to the place of constructability in VE studies

According to Figure 1, concepts C1-7 were defined in the conceptual planning phase. Meanwhile, concepts C8-15 were put in the preparation and implementation phase, and concepts C16-23 were carried out in the operation phase. Figure 5 shows that the concepts related to the solutions presented in the mentioned phases are shown separately based on their frequency. According to both diagrams, VE studies cover the principles and concepts of constructability at all project lifecycle stages. However, it is interesting that constructability as one of the functions of VE has received particular attention in the design phase. The majority of the existing studies in the initial phases confirm this issue. Based on this fact, however, as the project progresses, the impact of not paying attention to the design implementation and accuracy will affect the project's overall

costs. Thus, constructability should be noted at the early stages of the project, such as the design stage, to achieve a higher impact.

In the continuation of the review, considering the scope of implementing the solutions presented in VE, codes listed in Table 5 were grouped in a similar concept. New codes were assigned to thus with similar concepts in a subgroup. These three groups of management, engineering, and environment were under the scope of implementing the solutions presented in VE (see Figure 6).

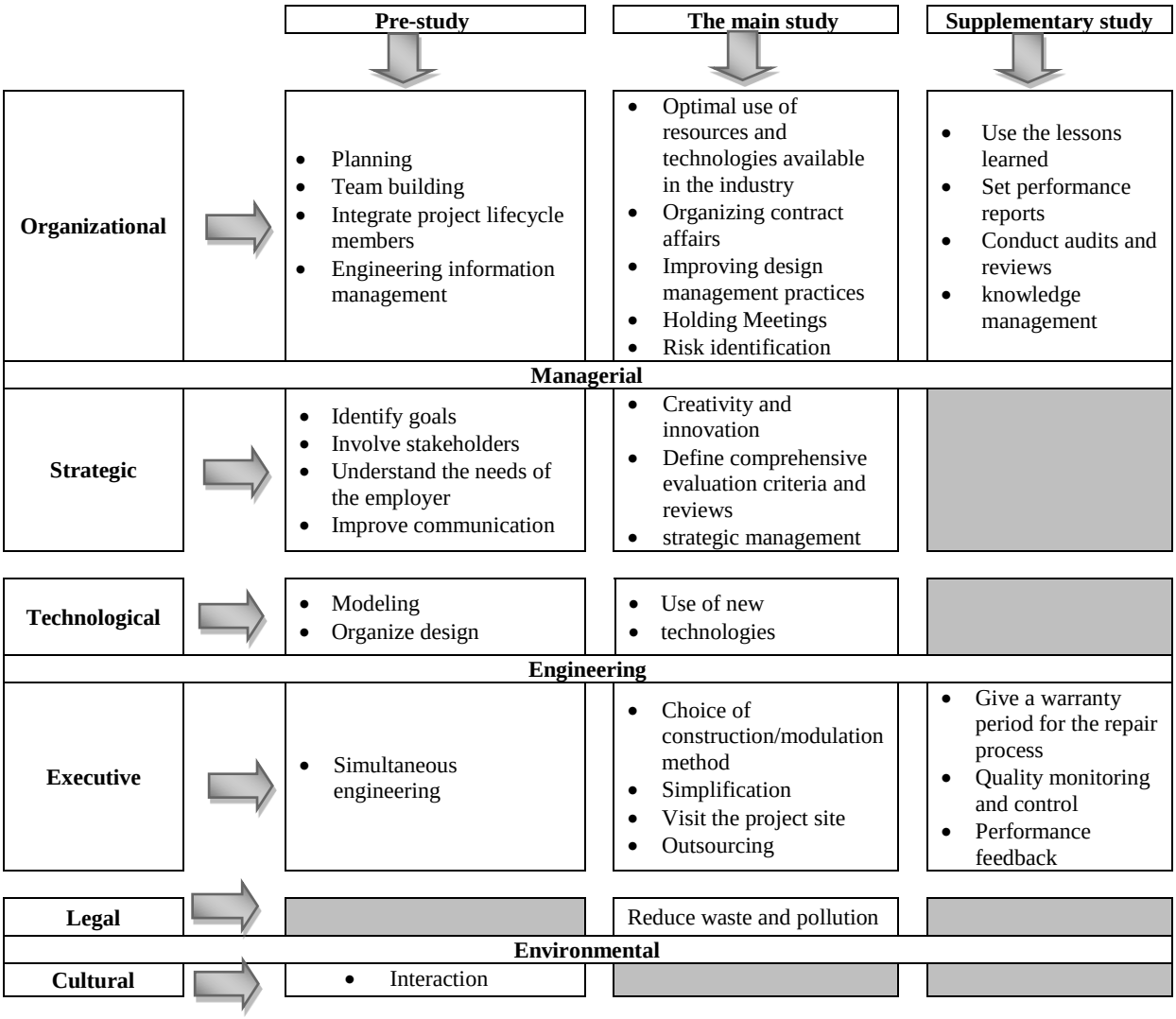

Figure 6 Coding pattern of the solutions presented in VE to improve constructability

In the vertical axis of Figure 6, three groups were defined, i.e., management with strategic and organizational subgroups, engineering with executive and technological subgroups, and the environment with cultural and legal subgroups. Then, the solutions with a nature appropriate to these groups and subgroups were included in the desired category. Despite being applicable to the nature of groups in the vertical axis, it is necessary to explain that these solutions were also classified according to the implementation phase of the solution presented in VE in the corresponding horizontal axis. For example, the team building solution is under the management solutions' organizational subgroup according to the vertical axis. This solution is significant in the VE pre-study phase considering the horizontal axis. In Figure 6, cases where a corresponding solution was not found in the defined phase, such as they were neglected or not studied, are shown with an empty box.

The results of Figure 6 are summarized in the following three items:

1. The majority of previous studies related to the place of constructability in VE focused on management solutions in the organizational and strategic fields, as well as the VE's pre-study phase main study.
2. The study gap in the legal aspects of environmental solutions is evident in the pre-study phase and needs more attention.
3. Despite their significance and positive effect on improving the place of constructability, environmental solutions (cultural and legal) had a small role in existing studies in all three phases of VE.

As mentioned earlier, it is necessary to ensure the implementation of value studies in the supplementary studies phase. However, various sections have been completely neglected in the studies related to the place of constructability in VE. These sections include an evaluation of the performance of management (strategic), engineering (technological), and environmental(cultural and legal) solutions.

The results of pattern coding extracted from the review in Figure 6 show that the most significant focus of studies on the place of constructability in VE was management principles and concepts. For instance, Al-Fadhli (2020) challenged this issue in a two-stage field study. In the first stage, the study identified the reasons for the failure of VE and constructability implementation in infrastructure projects. The obstacles to implementing these two techniques were identified by selecting several designs and construction experts in Iraq as the research's statistical population, and a questionnaire was distributed among them. The questionnaire analysis provided an integrated model for implementing VE and constructability in infrastructure projects. The proposed model was validated using the same statistical population in the second stage. The study found that the significance of constructability should be considered at all stages of the project lifecycle. However, it is emphasized that if there is a need to deepen the constructability technique as one of the functions of VE, it is better to pay special attention to it in the design phase. One of the reasons is that it can have the most impact. In this study, some management-organizational solutions were presented, among which we can refer to the "improving knowledge management" solution in the supplementary studies phase of VE. This solution implies constructability's P12 principle (the need for feedback). It improves the C23 concept (the need to document and record the lessons learned from the project) to enhance the constructability of the operation phase. In many articles reviewed in this study, the need to address this solution, which is one of the few studies focused on the supplementary studies phase of VE, has been repeatedly emphasized (Atabay & Galipogullari, 2013; Cha & O'Connor, 2005; Churcher, 2017; J. Mccuish & Kaufman, 2002; Miladi Rad & Aminoroayaie Yamini, 2016).

Presenting solutions such as "strengthening the relationship between partners", "possibility to use the experience of subcontractors," and "emphasis on improving the relationships between different parties" in this study and related to the pre-study phase of VE includes principles p1 (integration), p2 (construction knowledge), and P3 (team skills) related to constructability. It also covers five basic concepts for improving constructability in the conceptual planning phase (C1-5). This study refers to the solution of involving stakeholders in all phases of the project based on the p4 principle (defining the common goals) and concepts C1 and C2. They all emphasize the significance of the management-strategic dimension of the solutions presented in VE to improve constructability in the pre-study phase.

Similarly, addressing the solutions show the significance of different dimensions of the management group solutions in improving the place of constructability in VE. Some examples include the solutions focusing on "realistic planning" (Cha & O'Connor, 2005; Fong, 1996; Gambatese et al., 2007; Kusumi, 1989; Mccuish, 2010; Miladi Rad & Aminoroayaie Yamini,

2016); Omigbodun (2001) that covered P7 principle (plan) and concepts C1 and C5 and C8, or "strengthening team building" the studies that include principles P1 (integration) and P3 (team skills) and concepts C1 and C2 (Cha & O'Connor, 2005; Gambaese et al., 2007; Kusumi, 1989; Mccuish, 2010; Miladi Rad & Aminoroayaie Yamini, 2016) , as well as the solution of "improving engineering information management" (Austin & Thomson, 1999; Cha & O'Connor, 2005; Kusumi, 1989; J. Mccuish & Kaufman, 2002; Omigbodun, 2001) that includes principles P1 (integration) and P10 (project specifications) and concepts C6, C8, C10, and C12.

In other studies, Charles et al. (2017) conducted a case study and SWOT analysis in Nigeria to evaluate the impact of constructability and VE on construction projects. First, about 300 questionnaires were distributed among project managers, architects, engineers, consultants, and contractors. This questionnaire had two parts. The first part was intended to analyze the industry and identify the weaknesses, opportunities, and threats in the country's construction industry. In the second part, the questionnaire examined constructability and VE in the construction industry of Nigeria. The findings of this study showed a lack of serious focus on constructability in implementing VE in the construction industry in Nigeria. Thus, a framework indicates how integrating these two concepts can enhance knowledge and facilitate implementation. This study has stated other solutions, such as "identifying risks". These solutions are based on principle P6 of constructability (external factors affecting the project) and concepts C15, C10, C8, and C7. Again, in these cases, the significance of management group solutions was evident. This article referred to other solutions, such as examining the constructability of the presented designs using Building Information Modeling (BIM). In addition, it emphasized design modeling and organization, covering principles P11 (using technology) and concepts C18 and C9 related to improving constructability, which highlight the significance of engineering-technological solutions.

Other review studies (Gambatese et al., 2007; A. A. E. Othman, 2011) have referred to the significance and role of new technologies in VE studies to improve constructability. Solutions based on the implementation of simultaneous engineering and reducing the gap between the design and construction phases have been proposed, which emphasize the improvement of engineering-implementation solutions (Al-Fadhli, 2020; Chasey & Schexnayder, 2000; Pocock et al., 2006). Industrialization methods, such as assembly in construction and modularization (Cha & O'Connor, 2005; Hanlon & Sanvido, 1995; Mccuish, 2002; Omigbodun, 2001; Russell, Gugel, et al., 1994), and field visits and site management (Atabay & Galipogullari, 2013; En Mao et al., 2018; Miladi Rad & Aminoroayaie Yamini, 2016a) are among the other solutions related to the engineering-implementation group. These solutions focused on the main study phase of VE.

Another study by Omigbodun et al. (2001) examine dhow value engineering helps achieve an optimal solution to a design problem in the construction industry through an analytic comparison between several projects in the Middle East and West Africa. In that study, "constructive interaction between construction owners, designers, and builders" was introduced as a solution to improve constructability through VE. It is one of the few cultural solutions presented in the environmental group. As mentioned earlier, despite the significance of environmental issues from legal and cultural aspects, which have a significant impact on enhancing the place of constructability in VE, the existing studies have not addressed them in depth. It can be assumed that perhaps focusing on this field and strengthening various aspects of environmental dimensions will significantly affect other areas.

For example, improving the cultural growth of the organization and the flexibility of traditional thinking governing various aspects such as team building and improving communication will also be effective. In addition, concerning legal solutions, removing the obstacles related to law, such as competitive restrictions in tenders, will provide the context for more principled selections.

Therefore, it is helpful to conduct more studies in these neglected areas. This review covered various managerial-organizational aspects in the engineering-implementation group relatively well. These include the use of "recording the lessons learned", "preparing regular reports" (Churcher, 2017; DOT, 2015), "conducting audits and reviews" and "performance feedback" (O'Connor & Miller, 1995; Omigbodun, 2001; A. A. E. Othman, 2011), and covered solutions such as "guaranteeing the repair process" (Atabay & Galipogullari, 2013), and "monitoring, and quality control" (DOT, 2015; A. A. E. Othman, 2011). However, given the purpose of the supplementary studies phase, which is to ensure the implementation and application of the changes recommended at the end of the value study, this phase requires more attention. The focus on this VE phase was low, and attention to the issues related to monitoring and evaluating the performance of management-strategic solutions as well as environmental solutions in both cultural and legal subgroups was neglected in this phase.

5. CONCLUSION

VE workshops are expected to identify and improve alternative methods to meet the project needs that save the capital or operating costs for the project sponsor. Constructability is one of the techniques used to prevent problems and increase costs due to factors related to the efficient ability of the contractor to improve the project. This study aimed to evaluate the place of constructability in VE and to provide suggestions for its improvement. Thirty documents were selected, studied, and assessed using the overview method by applying the defined criteria for the review to achieve these goals. In this process, the position of constructability in VE was initially evaluated. It was determined which VE solutions include the principles and concepts of constructability. The density of existing studies on this topic primarily covers which stages of the project lifecycle. These solutions were classified into management, engineering, and environment. The reviewed articles summarized to what extent they are focused on these principles and concepts, in which VE phase these solutions are implementable. Yet, it was examined what solutions have been neglected and whether addressing them can create an appropriate context for improving the place of constructability in VE. Then, it was considered that each of these overlooked solutions requires more attention in which VE phase. In addition, given the neglected sections, some solutions such as trying to improve the cultural growth of the organization and the flexibility of traditional thinking governing it, or resolving legal obstacles such as competitive limitations in tenders, and the need to monitor and evaluate the performance of management-strategic solutions as well as environmental solutions were suggested in two cultural and legal subgroups. The purpose was to create a place of constructability in VE.

Prior to this research, the position of constructability in VE had not been evaluated in a focused and separate manner. It was unclear which VE solutions were implementable in which phase of the value project to improve constructability. The findings of this study indicated that a large part of the proposed VE solutions that cover the principles and concepts of constructability is focused on the pre-study and the main study phases of VE and the management subgroup. Significant areas related to the supplementary studies phase or environmental solutions, including cultural and legal issues, have been neglected. Hence, addressing them provides an appropriate context to improve the place of constructability in VE. Moreover, identifying and implementing them can pave the road for leading studies. Given the gap in existing studies and the lack of addressing the environmental solutions related to cultural and legal issues, it is suggested that future studies consider the output of the model analysis of this study as a basis for designing a framework to examine the degree of constructability in the VE project. Moreover, the present study suggests future research to identify the obstacles and enablers to facilitate their implementation while identifying the neglected environmental solutions through field research.

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RENEWABLE ENERGY FOR OVERCOMING THE DILEMMA OF DARKNESS IN NIGERIAN URBAN CENTERS

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ABSTRACT

Cities are unique centers of energy demand and greenhouse gas emissions. Although electricity provides multiple functions for urban residents, its supply in Nigerian urban centers is poor, and the attempts to understand this problem have been limited to national level. Therefore, this study aims to explore the dimensions of electricity supply problem; assess adaptations by households to inadequate electricity supply; examine the use of renewable energy-related facilities; and understand the perception of renewables by urban households, with five residential neighborhoods in Minna, the capital of Niger state, were covered. Data were collected using a questionnaire and the Facility Observatory Technique to document daily electricity supply to households. The collected data covered electricity connection, daily supply, adaptations to inadequate public supply, perception of renewable energy and willingness to shift to renewable electricity sources. Results indicate that households in Minna have an average of 5 hours of electricity daily, while only 25% have electricity at night (7.00pm and 10.00pm.). An index derived to demonstrate the nature of electricity supply to households indicates that the city has a darkness index of 0.81, indicating a situation of extreme inadequacy of electricity supply. The index has a 95% correlation with the proportion of households without electricity at night. The study also shows that 72% of the households use fossil fuel-driven plants while 84% are not familiar with the use of renewable resources for generating electricity. The paper holds that the willingness of the public to switch to renewable energy, the incremental nature of urban development, and the high costs incurred by households for non-sustainable alternative sources of electricity provide the foundation for a more concerted effort to develop renewable energy as a means of improving the availability of electricity in Nigerian urban centers.

Key words: Adaptation, Darkness index, Electricity supply, Energy, Perception

1. INTRODUCTION

Cities constitute a unique energy demand center and a significant source of greenhouse gas emissions due to the use of unsustainable energy types. In cities, energy is one of the most critical resource flows and is a primary driver of both the physical and economic systems (Doherty et al., 2009). Energy plays a vital role in contributing to sustainable development, poverty reduction, the development of the critical sectors of the economy, and the delivery of services such as water, health, and education (Oyedepo, 2012; Diji, 2013; Oladipo & Temitayo, 2014). The use of energy is strongly related to almost every aspect of development; wealth, health, nutrition, water, infrastructure, education, and even life expectancy is strongly and significantly related to the consumption of energy per capita (Lloyd, 2017).

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With these benefits, inadequate energy supply in urban centers attains different characteristics, adaptations, and impacts. Furthermore, electricity as a modern form of energy is central to urban social and economic activities. It is seen as a significant driving force of an economy and the fundamental source of development (Soneye & Ademola, 2011; Paul et al., 2015).

It is also established that electricity use and gross national product have been strongly correlated, with stable linear relationships over long periods (Hirsh & Koomey, 2015). Without electricity, people face many problems in their daily activities. For large companies, an electricity shutdown means economic losses due to failure in sustaining operations and other activities (Kamaludin, 2013). Thus, when there is unreliability or limited availability of electricity, the value and potential uses to households and businesses are drastically reduced (Greenstone, 2014).

Cities' energy demand is growing faster than the urbanization growth rate. Records from IRENA show that while global urbanization increased from 43.5% in 1990 to 54% in 2014, urban energy consumption rose from 45% to about 65% within the same period (Ferroukhi et al., 2016). Sugahara & Bermont (2016) shows that energy consumption in cities of OECD countries is substantially greater than that of rural areas. Urban energy demand will increase more quickly since its energy consumption grows faster than rural areas as it consumes more fossil fuels. Globally, in 2006, while fossil fuel constituted 86% of total energy consumption in urban areas, it was 69% in rural areas. The estimated energy consumption for cities and rural areas are expected to increase by 26.5%and 7% between 2015 and 2030, respectively.

Attention has been drawn to the poor energy situation in Africa (Quansah et al., 2016). According to Ouedraogo (2017), while the continent has energy resources that can sufficiently meet its energy demand, access to modern energy services remains limited. Similarly, IEA (2014) stated that electricity consumption per capita in Sub-Saharan Africa constitutes half of that of China, 20% of the average for Europe, and 7% of that of the USA. Sanusi & Spahn (2019) also demonstrated energy marginalization arising from the low deployment of alternative energy sources by the African nations, noting that the energy marginalized is the energy excluded and suffers the disadvantages associated with this form of ill-being.

A joint report by the IEA, IRENA, UNSD, and WB (2019) shows Nigeria's highly unacceptable energy supply status, which is among the top 20 countries with the most significant access deficit in electricity. With 55% of Nigeria's population lacking access to electricity, it ranks third after India and China. Similarly, Nigeria is among the 20 countries with the most extensive clean cooking energy deficit.

Generally, only 30% of the nation's current electricity requirements are met (Ebhota & Tabakov, 2018). In 2019, energy generation capacity declined from 4,209 MW in January to 3,524 MW in September (NERC, 2019). This low generation capacity is from a nation whose demand was projected to reach 45,490 MW in 2020. The country places heavy reliance on fossil fuels for electricity generation. Renewable energy contribution through hydropower has declined over the years. While hydropower's contribution to national electricity capacity rose from 32% in 1999 to about 40% in 2002, it fell gradually to about 20% in 2012 (Akande & Bickersteth, 2019).

Although most urban centers in Nigeria are connected to the national grid, the issue is the inadequate supply that has grossly affected the daily duration of electricity supply to households, institutions, and enterprises. While, on the one hand, the electricity supply to Nigerian urban centers reflects the generally poor access to modern energy in the country, it is also a source of informal and inefficient adaptation (Abiodun & Segbenu, 2017; Akande & Bickersteth, 2019; Okorie & Manu, 2016; Saifuddin et al., 2016; Sambo, 2008, Olatunji et al., 2018). Sambo (2008) noted that electricity demand in Nigeria far outstrips the supply and that the supply is epileptic despite the country's availability of vast natural resources. Sanusi & Owoyele (2016) also pointed

out that Nigeria's poor energy supply situation has created energy poverty among a substantial proportion of the population.

Some case studies have also shown the country's poor situation of electricity supply. In Ibadan, it was discovered that about 60% of the residents in the region receive less than four hours of electricity supply daily from the public source (Soneye & Daramola, 2011). According to Ado & Josiah (2015), small-scale businesses suffer from inadequate and unreliable electricity supply in the North-East geopolitical zone of Nigeria. As a result, these businesses are forced to invest a significant amount of their resources as backup facilities to self-provide electricity when the publicly provided power becomes unreliable or of lower quality. Generally, businesses from across the country experience average power outages of eight hours per day because companies and households rely on diesel generators for their electricity (Bagus et al., 2016). Paul et al. (2015) affirmed the extreme electricity deficiency in Nigeria. They noted pipeline vandalization, the difficulty of gas supply to electrify power stations, and strikes by unions in the electricity generation and oil companies as major problems undermining electricity generation in the country. Sambo et al. (2012) and Akhator et al. (2019) well documented renewable energy resources, though they have not shown the actual experiences households suffer in accessing electricity and paid little attention to households' adaptation to inadequate electricity supply. These constitute a gap to which this paper has directed attention.

The Federal Government has, in recent times, directed attention at increasing power generation through the grid and by using gas. However, experiences on the ground do not show that the efforts have yielded dependable results. Stagnation in power generation occurs in the face of growing population and urbanization with the attendant demand for economic activities that require substantial energy input. With these experiences, it is not surprising that there are frustrations in the use of electricity by the electricity consumers in Nigeria and a feeling that they are paying the public electricity provider for darkness. This paper aims to explore the dimensions of the electricity problem in Minna, the capital of Niger State, assess adaptation by urban households to inadequate electricity supply, examine the use of renewable energy-related facilities, understand the perception of renewables, and propose strategies to deploy renewable energy for sustainable electricity supply in the urban centers. This study has determined, in quantitative terms, the practical experience of daily darkness and deprivation in electricity supply. It reveals that while households' understanding of the use of renewable sources as electricity is poor, households are ready for a future shift to renewable energy. These findings are valuable for targeting the energy excluded and designing relevant policies for the sustainable energy transition.

2. RENEWABLE ENERGY AND URBAN DEVELOPMENT

The UN-Habitat (2010) stated that the use of energy, the types of energy used, and the lack of access to sufficient energy have far-reaching implications for cities, that include: (a) burning fossil fuels to provide energy with the consequences of contributing to carbon emission; (b) cities' commitment to sustainable energy; and (c) climate action plans to reduce their vulnerability to energy scarcity and energy price rises. In addition, sustainable energy, and climate action plan in cities of developing countries should consider users' needs first. Hence, attention should be given to poor households and small energy users.

Vandevyvere & Stremke (2012) identified the constituents of sustainable energy in cities as reducing energy demand, optimizing energy streams, and providing renewable energy. Ferroukhi et al. (2016) affirmed that renewable energy solutions are part of cities' broader sustainable development agenda. Hence, deploying them opens novel perspectives for decentralized supply structures of electricity (Cadera et al., 2016). Going renewable has become imperative for many

reasons; its mature, available, and ready-for-use technologies involve using local resources to produce energy locally.

The Global 100RE Platform (2015) stated that renewable energy provides decentralized energy production and distribution of benefits, achieves the idea of independence from finite and polluting energy resources, and ensures sustainable, secure, and affordable access to energy for all. In addition, renewable energy embodies a horizontal supply chain and innovation in infrastructure and energy markets, embracing new actors and stakeholders who claim ownership rights and have a direct impact. It is also important for tackling energy-related sustainability, achieving climate protection, creating local jobs, and helping to keep money circulating within the local economy (Global 100RE Platform, 2015) It is noted that the efforts to successfully limit global warming hinge on cities since cities consume much of the world's energy and produce more than 70 percent of global carbon emissions (UN-Habitat, 2020). Hence, while access to energy by the urban dwellers is essential, it is more important that energy sources are sustainable and devoid of the defects of conventional energy sources (Terrapon-Pfaff et al., 2018).

The decentralized nature of renewable energy fits quite well into the nature and mode of urban development. Cities are naturally distributed, and developments in each town are incremental. Distributed energy generation refers to off-site power generation on decentralized levels (Vinod et al., 2018). The decentralized nature of renewables practically transfers energy power to various geographical levels, a spatially democratized energy system. It is ubiquitous energy management where a renewable-energy-based economy provides small and medium-scale energy services that could replace the system of large-scale centralized ones (Droege, 2002), contributing to the idea of community energy and differentiated globalization.

In this respect, each additional urban development unit can match into new renewable energy development. According to Momoh et al. (2012), a decentralized energy system provides service at a higher level of reliability. Power quality from the grid has low variable and maintenance costs and operates between 50-3,000 hours per year to reduce overall electricity costs; arguably more resilient since it continuously serves low power demands. It also has 'wide acceptance for its favorable features in improving the overall efficiency of the energy system in terms of energy generation, economics, and environmental perspectives (Vinod et al., 2018). Decentralized renewable energy is not only a viable energy option but also delivers a basic level of universal energy access in a fraction of the time and cost of conventional approaches. Furthermore, it allows an extensive range of investors, customer-centered brands, ancillary services, innovation, and speed.

Energy sustainability is based on three core dimensions: energy security, equity, and environmental sustainability. These dimensions constitute the energy 'trilemma' (Kim et al., 2017). Cities will also be pursuing self-reliance in energy matters through a renewable-based decentralization of energy production (Morris & Oska, 2008) and work towards achieving resilience (Sugahara & Bermont, 2016). The link between renewable energy and the city is further demonstrated in Figure 1. Through the elements of distribution, demand, resources, green, and emission, it can be seen that the city has characteristics disposed to renewable energy on the one hand. For example, in terms of distribution, both the city and renewable energy are amenable to decentralized development. At the same time, the demand component indicates that while renewable energy can be provided at the point of demand, the city offers this ready demand. However, on the other hand, the figure shows that the poor emission characteristic of the city can be addressed by the low emission level of renewable energy.

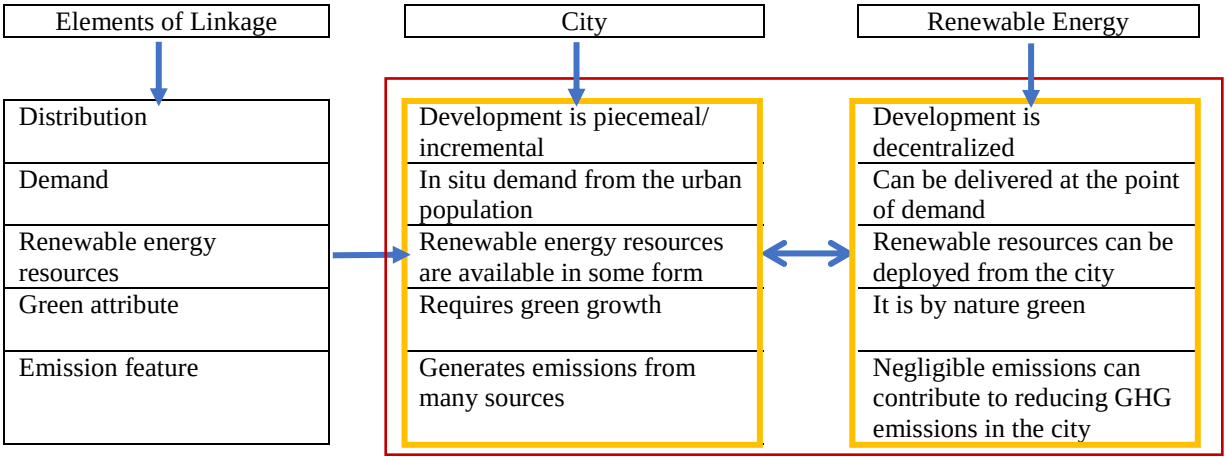

Figure 1 The links between the city and renewable energy

The correlation between the urban systems and environmental health, economic competitiveness, and the quality of life in cities is the patterns of consumption and production of infrastructures and investments in urban system infrastructure development used to achieve and sustain socio-economic development goals (Gómez et al., 2015). The cities' role in the transition to renewables lies not only in the advantages of renewables to them but also due to the leadership they provide in the transition process. Energy leadership consists of the whole range of initiatives, ability, and capacity to take responsibility for initiating, sustaining, and spreading the use of renewable energy resources. It means a strong belief in the sustainable opportunities that renewable energy offers and working to realize these opportunities.

Renewable energy leadership will vary as much as the diversity of the stakeholders in the investment and consumption of renewable energy, the regulatory authorities, and partners within and across nations. According to the UN-Habitat (2010), the critical role played by authorities of the cities in the energy delivery system is seen in the fact that they plan and manage city development and growth, establish and enforce building codes and approve building plans. Cities are the primary providers of essential services such as water, waste management, street lighting, and other related services and are responsible for transport planning and management, the distribution of electricity, filling, and generation capacity. As major employers, they can directly influence their employee's energy-use patterns.

The many ways cities take control of their renewable futures with engaging results include target setting, regulation, operation, consumption, financing, and advocacy (Ferroukhi et al., 2016). While all the ways of demonstrating energy leadership are essential, the advocacy role is central. Cities serve as powerful advocates, able to influence the behavioral choices of citizens and businesses by raising awareness about the benefits of renewables. Municipal authorities can also strengthen local capacities and skills in renewable energy through dedicated training programs. Energy leadership by cities leads to the pride of providing the direction and creating substantial national and international interests for the city and the energy projects (International Energy Agency, 2009). This leadership is critical to achieving Goal 7 of the SDG, mainly its Target 2, to substantially increase the share of renewable energy in the global energy mix.

3. METHODS

3.1. Data Collection

This study is based on Minna, the capital of Niger State, Nigeria. With its connection to the railway line, choice as an administrative center during the colonial administration, and choice as

the state capital in 1976, Minna experienced dramatic change in its urban status. These factors have been enhanced by the shift of the seat of Federal Government from Lagos to Abuja in 1992. Minna is only about 130 km from the Federal Capital Territory, Abuja. Using the national growth rate of 2.58% (World Population Review, 2020), the city had an estimated population of 496,362 at the end of 2019. Growth in population and socio-economic activities have implications for electricity demand.

The study covers five residential neighborhoods consisting of three high-density areas (Sauka Kahuta, Sabo Gari, and Minna Central) and two medium-density areas (F-Layout and Bosso Estate). The respondents cut across two major income groups; low-income earners (people in high-density areas) and middle-income earners (people in medium-density areas), as reflected by the residential areas. As shown in Figure 2, data were collected through questionnaire surveys and the Facility Observatory Technique (FOT) application. Major issues covered by the questionnaire include electricity connection, daily supply, adaptations to inadequate public supply, knowledge of renewable energy sources, perception of renewables in terms of quality and accessibility, and readiness to transit to renewables.

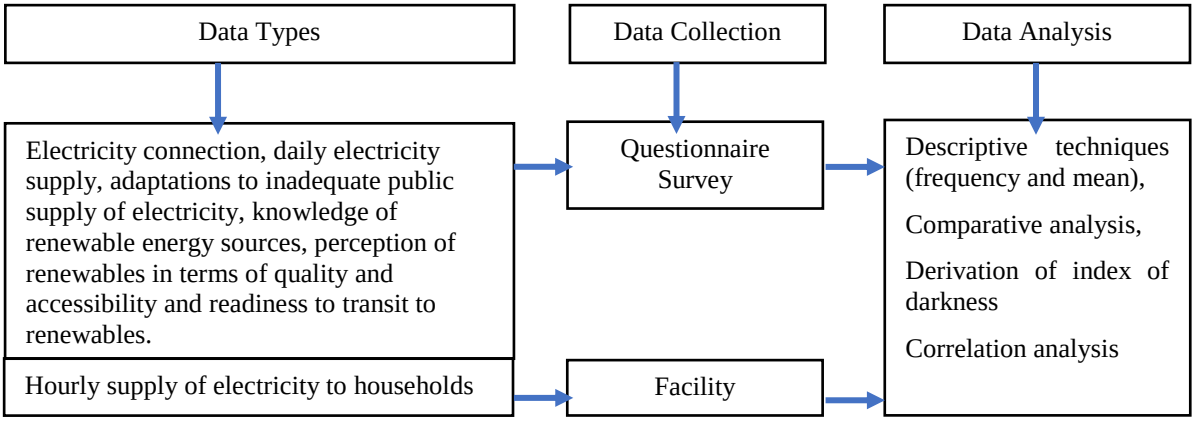

Figure 2 Data collection process

The FOT is a user participatory data collection instrument that requires observing critical elements of security of supply and recording the same hourly. Households recorded electricity supply for them over 17 hours daily for a week, from 7.00 am to 10.00 pm, drawing on the experience of an earlier study where an electricity supply monitor was used to examine the electricity supply to households in the Gbazango residential area of Kubwa, Federal Capital Territory, Abuja. Although the observatory depends on the goodwill, cooperation, and alertness of the households, it is adopted as an alternative to the households' giving a single response as to whether they experience electricity supply daily or giving a single figure for the duration of supply daily (Sanusi, 2008). The observatory is a participatory service monitoring system that captures the households' hourly service experience. The final average gives a more dependable figure for the electricity supply experienced by the households.

For the questionnaire administration, 200 households were selected from five neighborhoods. Similarly, 40 households were selected from each neighborhood for the electricity observatory. However, as shown in Figure 3, the returns for the observatory fell below 40, and hence the valid participants were considered for analysis: Sauka Kahuta (33), Sabo Gari (27), Minna Central (27), F-Layout (33), and Bosso Estate (15). These give a return rate of about 68%.

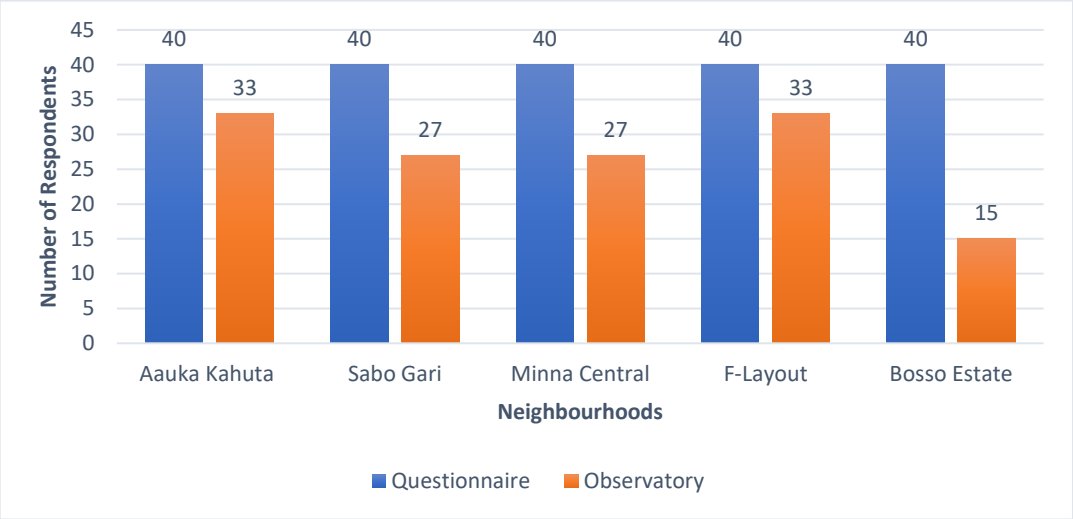

Figure 3 Distribution of Respondents for Questionnnaie and Observatory Technique

3.2. Methods of Data Analysis

Figure 2 also summarizes the methods of data analysis used by the study, done at both neighborhood and city levels. Data were analyzed through descriptive techniques using frequency and mean. Comparative analysis was then carried out to examine variations in electricity situation between hours of the day (night and daytime), the duration of electricity among the neighborhoods and household adaptation techniques. The analysis also measures darkness. Two measures of darkness were employed. The first is based on the proportion of households who do not have electricity supply between 7.00 pm and 10.00 pm that are considered critical to households for recreation, entertainment, cooking, and attending to children's school needs. Secondly is the derivation of the index of darkness. The index summarises the experience that households have in access to electricity daily. It measures the deprivation that households suffer in terms of electricity supply. It is given as:

$$Id \quad 1 - \frac{n}{N}$$

Where,

Id is the index of darkness

n is the average duration of electricity supply (in hours) daily

N is the number of hours in a day, and 1 is a constant representing a day

The index is measured on a scale of 0 to 1. The closer the index to 1, the higher the level of darkness experienced from inadequate access to electricity. Correlation analysis was applied to examine the relationship between the proportion of households without electricity daily, the proportion of households without electricity at night and the index of darkness.

4. RESULTS AND DISCUSSION

4.1. Electricity Condition in Minna's Household Level

Key issues examined in this section are the duration of electricity supply to households, measures of darkness, household adaptation to poor electricity supply, perception of renewable energy, and the willingness of the people to shift to renewable energy.

Table 1 shows the average electricity supply in the five neighborhoods over 17 hours daily. However, this is converted to a 24-hour supply by a factor of 1.41, as seen in Table 2. It is seen that, out of the seven days, no day has an exceptional display of electricity supply among the five neighborhoods. A better picture of the supply system is seen by considering the basic statistics, as shown in Table 3. The minimum daily duration of electricity supply per week in Sauka Kahuta is 1.53 hours, while the maximum is 4.41 hours. A similar pattern is seen in Minna Central, where the minimum supply duration is 1.43 hours, and the maximum is 4.52 hours.

Table 1 Seventeen-hour observation of daily electricity supply to households

Day	Soka Kahuta	Sabo Gari	F-Layout	Minna Central	Bosso Estate
Sunday	1.47	6.29	2.34	4.29	7.48
Monday	1.45	5.08	1.22	4.31	4.56
Tuesday	3.32	5.20	1.40	4.24	10.24
Wednesday	2.06	3.51	1.31	3.10	0
Thursday	2.03	3.35	3.0	2.53	1.52
Friday	2.38	4.07	3.45	4.00	8.36
Saturday	1.34	3.26	2.27	2.27	8.52

Table 2 Seventeen-hour observation of daily electricity supply to households

Day	Soka Kahuta	Sabo Gari	F-Layout	Minna Central	Bosso Estate	City level average
Sunday	2.07	8.52	3.18	6.03	10.32	6.02
Monday	2.04	7.09	1.43	6.04	6.26	4.34
Tuesday	4.41	7.20	1.58	5.58	14.26	6.37
Wednesday	2.54	4.56	1.50	4.22	0.00	2.34
Thursday	2.36	4.43	4.14	3.34	2.08	3.16
Friday	3.22	5.43	4.52	5.38	11.47	6.00
Saturday	1.53	4.35	3.12	3.12	12.01	4.50

Table 3 Basic statistics about electricity supply in Minna

Neighborhood	Minimum	Maximum	Mean
Sauka Kahuta	1.53	4.41	2.35
Sabo Gari	4.35	8.52	5.56
Minna Central	1.43	4.52	2.44
F-Layout	3.12	6.04	4.49
Bosso Estate	0.00	14.26	8.06
City level average	2.34	6.07	4.58
Number of neighborhoods below city level average	3	3	3

The neighborhood with the highest electricity supply in the week under account is Bosso Estate, where the maximum is 14.26 hours. However, even here, the minimum is 0.00 hours. Perhaps, the only neighborhood with a fair even daily distribution is Sabo Gari, where the minimum is 4.35 hours, and the maximum is 8.52 hours. Concerning the city average, the minimum hour of daily electricity supply is 2.34 hours, while the maximum is 6.07 hours. Against the city level average, three neighborhoods perform below the city level average in both minimum and maximum hours of supply. In the case of minimum, these are Sauka Kahuta, F-Layout, and Bosso

Estate, while in the case of maximum, the three neighborhoods are Sauka Kahuta, F-Layout, and Minna Central.

In terms of average performance per week, it is seen that Bosso Estate is the most served by electricity, with an average daily supply of 8.06 hours. It is followed by Sabo Gari, with an average daily supply of 5.56 hours. On the other hand, Sauka Kahuta experiences the least hours of 2.35 per day, with the city's daily supply being 4.58 hours. Sauka Kahuta, F-Layout, and Minna Central have average daily supply below the city's average. While the supply for the city is unacceptably low, these three neighborhoods are worse off compared to the city's average. Table 4 shows the households with electricity supply every day between 6.00 am and 11.00 pm.

Table 4 Proportion of households with electricity at any hour of the week

No.	Daily Hours	Sauka Kahuta	Sabo Gari	F-Layout	Minna Central	Bosso Estate	Weekly Average
1	6.00-7.00	5.2	3.7	3.0	4.6	0	3.3
2	7.00-8.00	2.1	6.7	4.2	4.8	4.0	4.36
3	8.00-9.00	2.1	20.7	14.2	23.7	9.3	14
4	9.00-10.00	1.2	51.9	24.2	28.5	30.7	27.3
5	10.00-11.00	18.7	59.8	32.1	45.9	42	39.7
6	11.00-12.00	22.4	65.6	36.7	48.5	40	42.64
7	12.00-1.00	30.3	57.4	16.1	47.8	39.3	38.18
8	1.00-2.00	25.2	41.1	22.4	23.3	39.5	30.3
9	2.00-3.00	20.9	23.3	13.3	23.7	26	21.44
10	3.00-4.00	27.6	17.4	13.0	23.3	8.7	18
11	4.00-5.00	18.1	14.4	26.1	10.7	4.7	14.8
12	5.00-6.00	11.2	7.4	7.2	10	0	7.16
13	6.00-7.00	4.8	7.7	1.0	5.2	1.0	3.94
14	7.00-8.00	4.8	28.8	1.7	22.6	60.6	23.7
15	8.00-9.00	3.9	20.7	1.3	25.9	69.3	24.22
16	9.00-10.00	3.0	19.6	4.2	20.0	70.7	23.5
17	10.00-11.00	17.9	13.7	13.0	21.1	77.3	28.6
Gross average/week		13	27	14	23	31	22

Figure 4 shows the city-level picture of households' electricity access throughout the day. It is seen that the early hours of 6.00 am and 9.00 am and the evening hours of 3.00 pm to 6.00 pm present the worst periods for households. Within these two periods, more than 80% of households do not have an electricity supply. Within day hours between (10.00 am and 1.00 pm), only 30% to 42 % of households have an adequate electricity supply. On the other hand, between 7.00 pm and 11.00 pm, only 23% to 28% of the households have a power supply. In four hours of the day, 6.00 am to 7.00 am, 7.00 am to 8.00 am, 5.00 to 6.00 pm, and 6.00 pm and 7.00 pm, less than 10% of the households enjoy electricity.

Electricity supply at night reflects the darkness in which the urban dwellers in Nigeria are thrown most of the time. Less than 30% of households enjoy electricity at night. This is an unacceptable condition. Moreover, the average picture blurs the variations among the neighborhoods, where the supply situation in Bosso Estate confuses the general experience of most residents. As seen in Table 4, between 60% and 77% of the households in Bosso Estate enjoy power supply between 7.00 pm and 11.00 pm. On the other hand, in all different neighborhoods, less than 30% of the households have a power supply within these night hours. The situation is deplorable in Sauka Kahuta and F-Layout, where less than 20% of the households enjoy power supply at night hours.

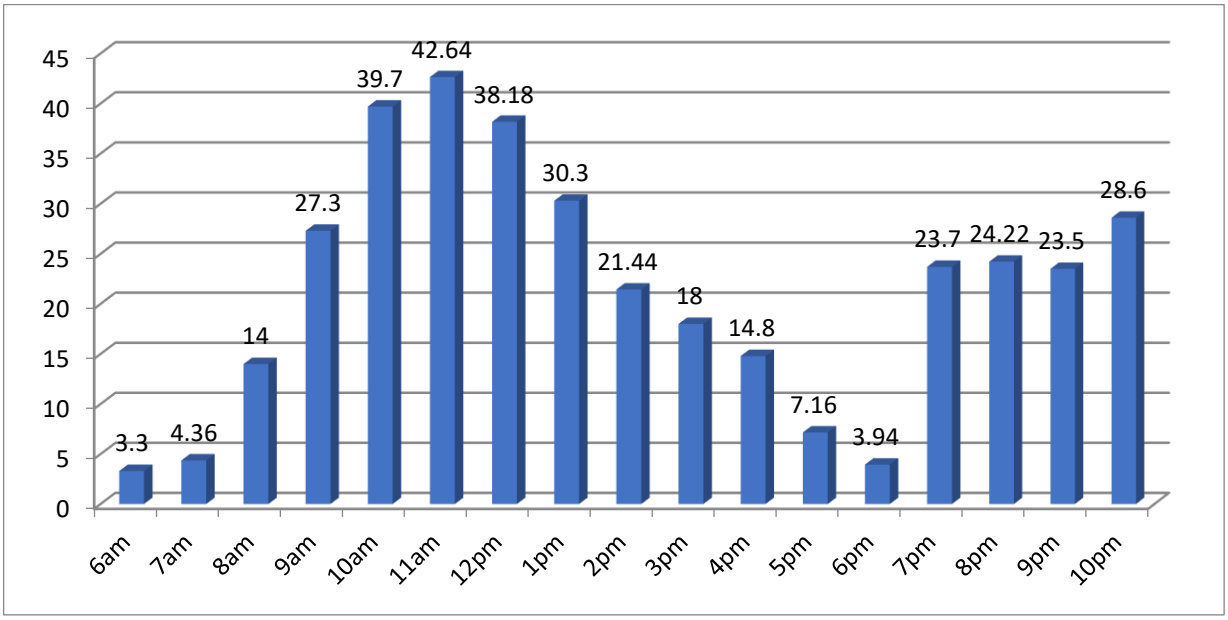

Figure 4 Proportion of households with access to electricity by daily hours

The alarming situation of energy poverty has been pointed to earlier by several previous studies (Akande et al., 2018; Ogwumike & Ozughalu, 2016; Ozughalu & Ogwumike, 2019; Sanusi & Owoyele, 2016). Ozughalu and Ogwumike (2019) noted that more than a fifth of the Nigerian population is affected by extreme energy poverty. In the Rafi Local Government Area of Niger State, the average electricity duration at the household level is 5.3 hours, 1.9 hours at the institutional level, and 4.3 hours at the level of business enterprises (Akande et al., 2018). With the results of this study, it is not difficult to agree that Nigeria is 'wallowing in darkness' (Paul et al., 2015).

Apparent factors cannot explain the neighborhood variations in the power supply because the inadequate supply is not sensitive to neighborhood types. For example, F-Layout is a medium-income residential area experiencing poor power supply. On the other hand, Sabo Gari fares better than most neighborhoods, although it is a high-density, low-income residential area. It is easy to associate its relatively better access to proximity to the city center (1,379 meters to the city center). However, F-layout (2,486 meters) and Minna Central (1,223 meters) are close to the city center. Indeed, Minna Central is the closest to the city center, although it has poorer performance than Sabo Gari. Although Bosso Estate is the farthest (5,792 meters to the center), it is better than all other neighborhoods. The irony of the power situation in Sauka Kahuta is that it derives its name from the step-down electricity transmission and distribution facility in the neighborhood. Yet, its power supply situation is among the worst.

4.2. Measuring Darkness

It is easy to see that Minna is often in darkness during most hours of the day. An index of darkness (ID) is derived to demonstrate this phenomenon. The index is derived from the ratio of the hours the electricity is experienced daily within the 24 hours. It is subtracted from unit one, which stands for a day. The index ranges from 0 to 1. The closer to 0, the lighter the community enjoys, while a more relative score of 1 is a pointer to darkness. The result can be seen in Table 5.

Table 5 Measures of darkness/light

Neighborhood	Daily power supply	Ratio to 24 hours	1-ratio (Index of darkness)	Percentage of households (daily)		Percentage of households (at night hours; 7.00 pm to 10.00 pm)	
				With light	Without light	With light	Without light
SaukaKahuta	2.35	0.10	0.90	13.	87	7	93
Sabo Gari	5.56	0.23	0.77	27	73	21	79
Minna Central	2.44	0.10	0.90	14	86	5	95
F-Layout	4.49	0.19	0.81	22	77	22	78
Bosso Estate	8.06	0.34	0.66	31	69	67	31
City Level	4.58	0.19	0.81	22	78	25	75

It is seen that all five neighborhoods experience darkness. The best index of darkness is achieved in Bosso Estate with an index of 0.66, while both Sauka Kahuta and F-Layout have the worst index of 0.90 each. By classification, a three-group category is made: communities with an index of less than 0.20 are experiencing a good supply of electricity, 0.2 to 0.50 are experiencing a moderate electricity situation, and communities with 0.51 to 1.00 are experiencing darkness. In this case, all the neighborhoods are experiencing darkness, with Sauka Kahuta and F-Layout areas in disadvantageous positions. In general, the city has a darkness index of 0.81. The experience of darkness is also seen in the proportion of households without light across the neighborhoods. It is done first concerning the daily hours and secondly concerning the night hours (7.00 pm to 11.00 pm). It is seen that overall, only 22% of the households experience power supply throughout the day as opposed to 78% thrown into darkness throughout the day (see Table 5).

Similarly, at night, only 25% of the households enjoy the light as opposed to 75% that experience darkness. The index of darkness correlates very well with the proportion of households without light daily and at night hours. Table 6 shows the correlation between the three variables. The ID correlates 0.969 (approximately 97%) with the proportion of households without electricity daily and 0.948 (about 95%) without electricity at night.

Table 6 Correlation between measures of darkness

Day	Index of Darkness	Households without electricity daily (%)	Households without electricity at night (%)
Index of Darkness	1.000	0.969**	0.948**
The proportion of households without electricity daily		1.000	0.846*
The proportion of households without electricity at night			1.000

** Correlation is significant at 0.01 level (2-tailed).

* Correlation is significant at a 0.05 level (2-tailed).

The index of darkness is a manifestation of energy poverty that may reflect general poverty, though different. Energy poverty demonstrates the home's energy deprivation problems (Bouzarovski & Petrova, 2015). The darkness index is to show that the deprivation in access to energy and enjoying the full range of energy services may impact the well-being and even the people's livelihoods.

4.3. Responses to Electricity Supply Situation

The households' experience in the public power supply has been presented. Without a doubt, energy supply is too important a need to be comfortable with its absence. In general, all households are connected to the public power supply. However, as demonstrated, most households experience poor supply situations. Table 7 shows the reactions of the households to the poor power supply situation. It is shown that while 17% of the households do nothing, 72% use fuel-driven generating plants, and another 5% use kerosene-fuelled lanterns to compensate for the deficiency in the public power supply. In addition, Table 8 shows households' daily quantity of fuel used to run the respective plant, where 2 to 20 liters of fuel daily need to run the generating plant. While in the end, one household uses 7, 8. 9, 12, 19 liters and 20 liters, respectively; most households use between 2 to 6 liters daily to run their plants. The households using 2 to 6 liters account for 58.5% of the total households.

Table 7 Alternative energy sources employed by households

Alternative energy source	No. of households	Percentage of households
Use of fuel-driven generating plant	144	72
Use of kerosene lantern	10	5
Touch light	12	6
None	200	17

Table 8 Quantity of fuel used by households to run generating plant

Quantity of fuel (liters)	Number of households (x)	Total Quantity	Percentage of households (x/200) %
2	20	40	10
3	24	72	12
4	26	104	13
5	31	155	15.5
6	16	96	8
7	1	7	.5
8	1	8	.5
9	1	9	.5
10	15	150	7.5
12	1	12	.5
19	1	19	.5
20	1	20	.5
None/no response	62	31.	31
Total	138	692	100
City average		5.0	

Across the neighborhoods, the average fuel used by the households daily is shown in Table 9, in which more than 72% of the households in F-Layout, Minna Central, and Bosso Estate use fuel-driven generating plants.

Table 9 Alternative energy sources employed by households

Neighborhood	Households that use fuel-driven generating plants (%)	Average fuel used to drive generating plant (in liters)/household/day
SokaKahuta	63	4.3
Sabo Gari	50	4.4
Minna Central	78	4.6
F-Layout	83	5.9
Bosso Estate	86	5.8
City Level	72	5.0

Similarly, the average fuel used per household is also shown in Table 10. While three neighborhoods have an average of fewer than 5 liters per household, two areas have an average of more than 5 liters per household. F-Layout and Bosso Estate have average use of fuel above the city's average of 5.0 liters. The highest of 5.9 liters per household is found in F-layout.

The inadequacy of electricity has attracted an adaptation system fraught with many problems. From the cost perspective, the adaptation imposes an extra cost on the households. Here, the average fuel for running a private generating plant per household can be recalled, and the cost associated with it is estimated, as shown in Table 10. Across the neighborhoods, daily expenditure ranges from Nigerian Naira (NGN) 623.50 in Sauka Kahuta to NGN 855.50 in F-Layout. On a monthly basis, it varies from NGN 18 705 to NGN 25 665, and at the city level, an average of NGN 21 750 is spent per household per month on fuelling the generating plant. The plant operates only for a few hours of the night for the households, mainly between 7.00 to 10.00 pm, and is a familiar sight within residential and business areas. It is not a surprise that estimates put Nigerian households' expenditure on fuel for generators at NGN 1.6 trillion annually (Olaoye et al., 2016**)**.

Table 10 Alternative energy sources employed by households

Neighborhood	Average fuel used to drive generating plant (in liters)	Average cost per day at 145 NGN per liter	Average cost per month
SokaKahuta	4.3	623.5	18705
Sabo Gari	4.4	638	19140
Minna Central	4.6	667	20010
F-Layout	5.9	855.5	25665
Bosso Estate	5.8	841	25230
City Level	5.0	725	21750

In addition to cost are the environmental effects of the plant and the threats to people's life. There have been cases of the fumes from the plant killing some or even whole members of households.

4.4. Readiness and Perception Towards Renewable Energy

With the recent experience of electricity supply in the city, it is natural that people have begun to see sustainable, dependable, and efficient alternatives with less running costs. Hence, the

residents of Minna attempted to investigate familiarity with renewable energy. In addition, other questions probe readiness for adoption, readiness to cooperate in deploying renewable energy and current use of renewable-based gadgets, and the various ways the households perceive renewable energy.

Table 11 Familiarity with renewable energy technology

Renewable Type	Households (%)	
	Familiar	Not Familiar
Wind	22	78
Solar	17	81
Geothermal	10	90
Ocean	19	81
Small hydropower	21	79
Solid waste-based energy	6	94

Table 11 shows a high level of ignorance regarding renewable energy technology. While for wind energy, 22% of the people are aware of its use in generating energy, it is 21% for small hydropower and 19% for the case of ocean energy. Even solar energy does not have the popularity that it should have. Hence, while solar with readily available technology is less known, others with less easily reached technology are more known. Overall, the familiarity level for the six renewable energy sources is 16%, as opposed to 84% of the households that do not know that the various renewable energy sources can provide energy for their use. However, ignorance is not seen in using gadgets powered by renewable energy. Table 12 shows that 13% of households use solar PV directly or indirectly, while 71% use solar energy-driven devices.

Table 12 Use of renewable energy facilities

Renewable Type	Households (%)	
	Using	Not Using
Solar PV	13	87
Solar gadgets (touch)	71	29
Average	42	58

Solar PV is not particularly popular even in the face of gross inadequate power supply. However, gadgets run by solar are. It is not uncommon to see solar calculators, torches, and fans in households. In terms of perception of renewable energy, it is seen that the perception of renewable energy is not disappointingly negative. Only 4% of the people feel it does not fit into their culture and believe it is a poor energy source.

Similarly, only 19% of the people believe that renewable energy is for highly educated people (Table 13). However, 60% of people claim it is expensive in financial terms. The fear of the financial burden is perhaps a significant factor in people's knowledge and use of renewable energy.

Table 13 Perception of renewable energy sources by the people

Perception	Households (%)	
	Yes	No
Energy sources that do not fit into culture and tradition	4	96
Energy source for the highly educated	19	81
Expensive form of energy	60	40
Poor source of energy	4	96
Energy with very high technology	27	73

The positive perception is reflected in the willingness to adopt renewable energy and cooperate with community efforts for its deployment. In general, 95% of the people are willing to use and collaborate to ensure the deployment of renewable energy. Only 2.5% are indifferent and not ready (Table 14). In responding to the issue of willingness, households express themselves freely, as shown in Table 15.

Table 14 Expression of willingness to cooperate in deploying renewables

Willingness	Number of households	Percentage
Very willing	104	52
willing	86	43
Not willing	5	2.5
Indifferent	5	2.5

Table 15 Opinions on willingness to use renewable energy

Outright expression of willingness	Conditional willingness	Skeptical/not willing
I can't wait to become a user We are eager to use it. Renewable energy is preferred in this situation (of the poor power supply) Looking forward to seeing more of these renewable energy sources To help me use more of my gadgets Very curious It will be helpful without depending on NEPA	If it is readily available and affordable If the government can provide solar energy, I am willing Very willing to use it but considering the cost.	I don't trust the government It is Needless Discouraged because of the nondurability and expensiveness I am indifferent about it as it is sometimes unreliable

People who express a high willingness to use renewable energy reflect the energy possibilities that renewables can offer to them. For example, a respondent says, ' to help me use more of my gadgets'. Another respondent also sees the need for freedom from the national body in charge of electricity, believing that 'it will be helpful without depending on National Electric Power Authority (NEPA). People who express conditional willingness to use and cooperate with community efforts to deploy renewables hinge their conditions on cost, availability, and government willingness. The government dimension is also seen in the skeptics who distrust the government's ability to make renewables available. There is an overwhelming willingness to cooperate in deploying renewable energy.

There is a clear emphasis on a short-time approach by the households in seeking a solution to the power supply problem. It is seen in their choice of alternatives (fossil fuel-based generating plants) and their attitude to energy shifting. While they are willing to cooperate in the deployment of renewable energy, they are faced with the problem of inertia in taking the risk of using renewables. The constraints in using renewable energy identified by the people are similar to what cities transitioning to renewable energy have specified, as shown by Jacquet (2015). These constraints include lack of jurisdictional control, lack of political will, vested interests in fossil fuels, and limited financial resources and public support. Wojuola & Alant (2017) showed that the concern for the cost of renewable energy sources and fear of the maintenance of the renewable plants are some concerns raised by members of the public in using renewable energy.

Similarly, Akinwale et al. (2014) show that the public members are aware of mainly hydro and solar PV and their operations in generating electricity. Although there are policy commitments and some actions to achieve renewable capacity in Nigeria, the glaring picture does not portray hope for an acceptable energy mix. Between 2012 and 2021, the renewable energy capacity increased marginally from 2132 MW to 2154 MW (IRENA, 2022).

5. CONCLUSION

The study has shown the poor state of electricity supply in Minna. It has shown that the energy supply is not only inadequate but also that accessibility by households to this service is grossly low, conditioning a clear energy poverty situation. The index of darkness provides a simple but realistic way to determine deprivation in energy access and possible consumption by people. It is seen that most households operate under conditions of darkness with an attendant lack of the full range of energy services. Most households are not aware of the fact that electricity can be generated from renewable sources. However, a good percentage of them use gadgets powered by renewable energy. Interestingly, people are ready for an energy shift to renewable sources. It offers hope for an active policy shift that emphasizes renewable energy development.

As part of the way out of the present darkness in Nigerian cities, renewable energy has to be adopted and pursued as a dependable and sustainable energy source. The adoption by all levels of government in general and the state government is a significant step for any follow-up actions. The ignorance on renewables must be removed by calling for effective energy citizenship that sees all energy end users as substantial participants in the renewable energy system, co-producer, and co-consumer approach, in which the risk and the benefits are well understood and shared. The decentralized nature of renewable energy should be employed to suit the piecemeal nature of urban development. Hence, housing estates, economic centers, and new neighborhoods should be separately provided with renewable facilities.

Similarly, reconsidering the investment system is necessary to create a new set of micro scale to small scale investors that fit the incremental urban development process. Micro-scale investors will be able to cover smaller areas and be able to recoup their capital within the shortest time possible. More active federal actions are required to push the transition forward. The current approach does not show enough bite to the energy problem through renewables. The elements of the renewable energy policies are good enough, but without the necessary push, the guidelines will have very little relevance. The Federal Government must change the super-dominance posture on energy by being more collaborative with the lower levels of government. A decentralized energy system allows the lower levels of government to control renewable energy resources and use them more sustainably. All the conventional and non-renewable energy investments clearly show that the centralized approach has failed. The energy sector has become an octopus that drains investments with little output. Per household/enterprise expenditure on energy is not lacking. Given the inefficiency of these expenses, they should be directed to more

sustainable energy sources that renewables represent. Therefore, what is essential is to pool the separate expenses of households and businesses together and lead these into renewables. There are currently many sources of loans, such as specialized banks and microfinance facilities, including microfinance banks and cooperative societies. A renewable energy deployment process that considers all these sources with the push to deliberately encourage households and businesses will be highly helpful in changing access to energy and ending the era of darkness in urban centers. Urban planning must also take the energy transition need into account in the planning and design of cities. As a result, facility planning for neighborhoods and units of urban centers must also sufficiently incorporate renewable energy options. In general, it should be realized that the energy shift is not only a necessity but also a multi-stakeholder affair. It is also a multi-source issue that should, from the beginning, involve as many renewable sources as possible, considering the renewable energy resources of cities and their regions.

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UNDERSTANDING THE IMPORTANCE AND FACTORS OF PARTICIPATION IN THE URBAN PLANNING PROCESS: A CASE STUDY OF NIGERIA

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ABSTRACT

Studies show that most urban planning systems in many countries still rely on expert-driven, top-down technocratic plan-making processes rather than a public and people-led process. The objective of this paper is twofold: (a) to evaluate the need for public participation in the plan-making process; and (b) to highlight the factors that affect public participation in the plan-making process. A qualitative approach is adapted to obtain these objectives by conducting observations, document studies, and interviews with real-world phenomena. The Metropolitan Area of Abuja, the capital of Nigeria, is examined as the case study. The research finds that public participation and engagement contribute to the plan-making process by identifying the critical urban issues unique to the specific local areas, establishing priorities, and mobilizing resources to meet the identified needs. It also shows that the development of a participation model by city authorities encourages public engagement and helps develop trust between the authorities and various key stakeholder groups. When the public is engaged in developing a particular plan, they become more invested. As they are more inclined to accept, promote and defend it, plan implementation can be enhanced.

Keywords: Plan-making; Participation; Urban planning

1. INTRODUCTION

The theory and practice of urban planning in most urban planning systems have changed over the years from a spatial and development-oriented approach to an institutional, policy-driven, and communicative approach based on participation, collaboration, learning, and consensus-building (Ozgur, 2013). In the 18th and 19th centuries, urban planning was conducted with a top-down approach (Cin & Lyddon, 1995; Fainstein, 2003). The local governments had limited or no independent legal authority and operated under the strict hierarchical control of the national government. This urban planning practice has recently been heavily critiqued for its top-down and outcome-oriented approach that excludes participation and social inclusion in urban planning applications (Fainstein, 2003). In the mid-19th century, urban planning, termed the modernist dream, was usually seen as planning to organize urban space. It was described as a rational, comprehensive, technical, and bureaucratic process and seen as a process involving producing a detailed plan of some desired future end-state to be achieved within a particular timeframe heavily oriented toward the concept of the rigid and unsustainable masterplan (Ozgur, 2013; Hall & Tewdwr-Jones, 2011).

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Hall (1989) argued that post-colonization urban planning destroyed vibrant urban neighborhoods by employing a top-down approach without involving the public in the planning processes. It seldom acknowledged the needs of the people to control their environment. It zoned and segregated communities according to socio-economic class and failed to come to terms with the livelihood realities of most urban populations (UN-Habitat, 2009; Kamete, 2013).

Later, in a move toward more inclusive urban planning, most western governments transferred powers and responsibilities for the urban planning of cities and municipalities to local authorities. It resulted in a shift from the top-down approach to a bottom-up approach to identify and meet the local community's needs (Cin & Lyddon, 1995). In this model, local authorities elected by local communities are responsible for urban planning decisions, involving all stakeholders (Healey, 2006). In this participative urban planning concept, tracing the possible consequences of alternative local policies and evaluating them against set objectives to choose the most appropriate action is emphasized (Healey, 2006; Hall & Tewdwr-Jones, 2011). It must be an ongoing process, with the monitoring, evaluation, and re-ordering continuing throughout the planning and implementation.

Since the beginning of the 21st century, most urban planning systems in developed countries have employed the collaborative planning approach by identifying and incorporating stakeholders' concerns, needs, and values in the decision-making process (OECD, 2009). This shift from a view of urban planning as an expert-driven technocratic activity to one inclusive of relevant stakeholders and communities is one of the most basic moves in the area (UN-Habitat, 2009). The urban planning approaches over the decades are summarized in Table 1.

Table 1 Urban planning approaches

Era	Fundamental approaches in urban planning
1900-1960s	• Comprehensive, rational, modernist • Physical design and development of cities
1960-the 1980s	• Community participation • Environmental concerns • A shift from physical design to social concerns
The 1980s-2010	• Collaborative, strategic • Participation of all parties in the planning process • Project-based development of cities • Upgrading quality in urban centers • Environmental concerns

Collaborative urban planning involves the progression of normative ideas and agendas by facilitating diverse initiatives from different stakeholders (Healey, 2006). It is enhanced based on consensus to help create social, human, and political capital among these groups. The collaborative urban planning theory recognizes the importance of building social capital and networking amongst other groups through participation in the plan-making process, which sees planning as an interactive and communicative process where planning issues are deliberated between stakeholders (Fainstein, 2000; Healey, 2006). The United Nations indicates that urban planning systems need to reflect a new awareness that integrates all its components holistically to meet environmental, social, economic, and governance needs for society to achieve effective urban planning practice (UN-Habitat, 2012). Considering the benefits, this study examines the importance of public participation in urban planning and critical factors affecting it, particularly using Abuja, Nigeria, as the case study.

2. LITERATURE STUDY

2.1. Urban Planning Process

Slack & Cote (2014) highlighted that developing a plan depends on the skills and experience of the relevant urban planning system. It must consist of a straightforward process and urban planning strategy that uses all the technical potential of the urban planning authorities in terms of personnel, instruments, rules, and regulations (Goggin et al., 1990). These strategies and development plans should recognize the broader policy context and set out a strategic spatial framework and a clear view ahead of the area the development plan covers (Schwedler, 2011). Urban planning processes are not necessarily well defined but often messy, involving similar activities and phases, dead ends, and iterations (McEvoy et al., 2018). It is well conceptualized by Schmid (2017), as shown in Figure 1.

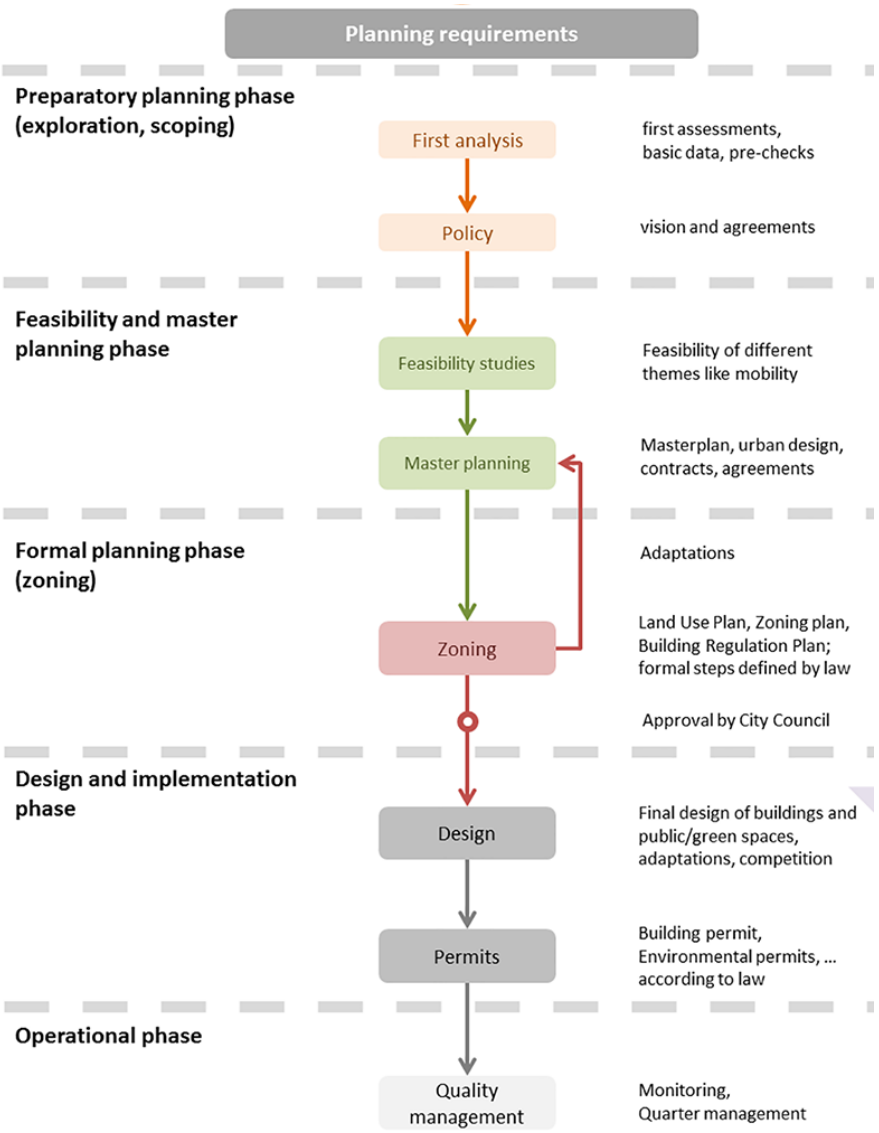

Figure 1 Diagram showing the different phases in the urban planning process (Schmid, 2017)

The urban planning process is conducted with frameworks through development strategies and plans at different levels, including national, regional, city, neighborhood, and specific sites

(European Commission, 1996). The interaction between the economic, social, environmental, and institutional aspects is essential to ensure more explicit links between the various urban planning processes (European Commission, 1990). The World Health Organization / WHO (1999) stressed that decision-making should happen at the highest level in the urban planning process and at all levels to help maximize participation in and the effectiveness of the urban planning process. Furthermore, building partnership between the service providers, stakeholders, and users is essential to establishing a sound and viable urban planning system that balances the diverse interests of sustainable development, business, and specific interest groups.

Context plays a vital role in how the urban planning process is developed and the outcomes that can be achieved. As Basco-Carrera et al. (2017) outlined, urban planning processes happen within a context created by different factors, such as local political climate, regulations, physical characteristics of a site, and economic conditions. And the outcomes of those urban planning processes impact the system and the stakeholders involved (Hassenforder et al., 2015). Hall & Tewdwr-Jones (2011) perceived urban planning as a sequence of processes constantly reiterated through a return loop, where urban planners start by formulating broad goals and identifying societal needs. It then leads to the idea development based on the set objectives, followed by the action implementing the preferred alternatives.

2.2. Participation in the Urban Planning Process

2.2.1. Concept of Participation

Participation can be seen as taking part in the formulation, passage, and implementation of public policies, with actions aimed at influencing decisions made by public representatives (Parry et al., 1992). It can be categorized broadly as (1) participation as a means and (2) participation as an end, which are not mutually exclusive. An effective urban planning process involves both types of participation. Participation aims for more effective implementation of programs and projects through active public involvement in project implementation through labor, financial, or in-kind contributions. While participation as an end sees the public come up with solutions and ideas, participate in the urban decision-making process, and take responsibility for the management process (UN-Habitat, 2007; Parry et al., 1992). Furthermore, readiness to commit human capital and financial resources for implementing plans and partnership of different stakeholders indicate participation as both an end and means.

Mansuri & Rao (2013) saw participation as a ‘top-down’ approach. They argued that the focus on participation in the urban planning process is a reaction against large investment plans and the social costs of structural adjustment. North American Aerospace Defense Command or NORAD (2013), on the other hand, made a strong case for a more bottom-up and deliberative vision of plan-making that allows for communities’ common sense and social capital to play a central part in decisions that affect them. He saw this as driven more by ideology and optimism than theoretical or empirical systematic analysis. Gaventa & Barrette (2012) noted that the meaning of participation in the urban planning process has expanded from engagement or involvement in community projects to participation in policy. This concept of participation is central to the idea of the citizen, understood as someone with rights, aspirations, and responsibilities concerning other community members and the state (DFID, 2010). Effective participation enhances individuals’ capacity to improve their lives and mobilizes vulnerable groups (Cleaver, 1999).

Marzuki (2015) remarked participation is a process, not a product, in which the urban planners know the people and their situation well enough as a resource. It has evolved from planning ‘for’ the people to planning ‘with’ the people (UN-Habitat, 2010). Goodspeed (2008) described participation in planning as a public process that includes politicians, civic activists, business

leaders, the media, the public, etc., engaging in the public conversation about urban planning issues.

The public is involved in urban planning when the issues at stake relate directly to them. Therefore, it is vital to involve them from the beginning to the final stage, from where the significant problems are identified to where the decisions are taken (Andre et al., 2012). Legacy (2017) believed that every citizen must participate in the decision-making process at all levels because policies and developments affect everyone in society. Inadequate stakeholder engagement from the early stages of urban planning can lead to tensions, disputes, and project delays (ADB, 2014). Public participation promotes public awareness, encourages the feeling of ownership, strengthens urban management instruments, and encourages community development (Ker Rault et al., 2013). This engagement enables good governance, citizenship, and accountability and promotes innovation, responsiveness, and sustainability (ADB, 2014). Furthermore, a better understanding and well-informed decisions can be achieved when all stakeholders are included in the participation (Wesselink et al., 2011). Different stakeholders can develop and implement public policies with public involvement through interaction with government agencies, political decision-makers, third-sector, non-profit organizations, and business organizations (Quick & Bryson, 2016).

2.2.2. Effectiveness of participation in the urban planning process

Effective participation in the plan-making process stimulates information exchange between the proposed urban planning stakeholders, enhancing their understanding and relationship, which leads to real social change (Glass, 1979; Cavric, 2011). It is not only about giving disadvantaged individuals or groups a voice at the table; it is about strengthening their capacity to influence decision-making processes and exercise their claims on external actors affecting their lives (Dugarova & Utting, 2013). However, effective public participation is difficult to achieve if the residents are not equally represented within or as part of the whole group of stakeholders (Bramwell & Sharman, 2000). Representation does mean not only public access to decision-making processes but also the ability for all stakeholders to have knowledge of and understand and contribute to any proposed development. Public participation efficiency and effectiveness can be compromised by challenges faced by the public when it comes to an understanding technical report and complex urban planning issues (Jenkins, 1993). It can consequently affect the public's ability to comprehend the decision-making process (Marzuki, 2015).

Hopkins (2001) considered the effectiveness of participation in urban planning under five themes: (1) Participation of more diverse people increases group capabilities to make plans; (2) Participation of decision-makers increases the likelihood they will use the plan; (3) Participation of all constituencies avoids later resistance to chosen actions; (4) Participation outside of formal democratic processes compliments these processes by giving different people access and thus representation; and (5) Participation's experience helps create the kind of individuals necessary to operate a democracy.

Public participation is self-amplifying; it is not designed to improve immediate decisions about plans simply or to increase an action's success rate but to sustain institutionalized systems and give the underpowered a platform (Reardon, 1994; Hopkins, 2001). Goldsmith (1998) took a different view by noting that participation is expensive and that most people do not have time to participate in planning when they are more concerned with trying to make a living. Effective participation in the plan-making process fosters human development, enhances the sense of political influence, reduces power concentration, nurtures a concern for collective problems, and contributes to forming active and knowledgeable communities capable of taking an active interest in urban planning issues (Pateman, 1970). But for this to be effective and efficient, Schuler (1996)

argued that the participation process should be community-based, reciprocal, contribution-based, unrestricted, adaptable, accessible, and inexpensive.

Participation is not a one-time effort but a process that must continue throughout the project or activity (Goodspeed, 2008). This process develops through several stages depending on the project's character and nature, from receiving information to the stage where stakeholders become partners and assume responsibility for management (UN-Habitat, 2007). Participation reflects the three citizens' fundamental rights: the right to be informed, the right to be heard, and the right to affect activities directly related to their living conditions. The right to be informed is achieved via access to information, while the right to be heard is obtained through consultations and consensus building. The right to affect those activities is realized through inclusion in decision-making, risk sharing, partnership, and self-management.

Public participation ensures the effectiveness of the plan-making process, improves the quality of outcomes, and validates the decision-making process (Cilliers, 2014). It is not achieved when politically motivated; it relies on deliberative considerations of what ought to be done and on learning enough about the options to express a preference for a plan (Stevens, 1993). Hopkins (2001) argued that involvement in plan-making has to be, or perceived to be, beneficial to the person or organization participating; thus, the people should be encouraged to contribute to planning for different objectives (Keating & Krumholz, 1991).

Significant factors considered for effective public participation in urban planning include the legitimacy of the involvement, diversity of stakeholders, and social inclusion (Konsti-Laakso & Rantala, 2018). Emphasis should be placed more on representation and meaningful public participation and less on quantity. Representative public participation involves a process that includes members of the people who represent a broad range of views and values in the community (Kelly, 2010). It consists of the public as part of the planning from the beginning and ensures that they influence the plan through participation (Potsonen, 2013). Attention must be paid to what kinds of stakeholders participate and how the participation is conducted (Fung, 2006). Moreover, the citizens should be sufficiently empowered to be willing to engage in the decision-making process (Santos et al., 2017). The participation process must include actors with a solid technical background who can understand the process and the needs and requirements of the society (EEA, 2009).

2.3. Factors Affecting Participation in the Urban Planning Process

2.3.1. Stakeholders' Identification

The success of an urban planning process depends on the nature and mix of the different stakeholders included in the process. Cilliers (2014) highlighted that the participatory process mustn't be forced on anyone; instead, it should rely on the willingness of the relevant stakeholders to participate out of interest, curiosity, or responsibility. They may consist of individuals who use the place, have an interest in the place, or would be affected if the place were lost, as well as professional stakeholders with expertise, such as designers, engineers, planners, local authorities, developers, NGOs, and other affected parties, selected objectively and cover various sectors and interest fields (Breman et al., 2008). As shown in Figure 2, the size and extent of the plan should determine the specific list of stakeholders involved in the process (Stiles, 2012).

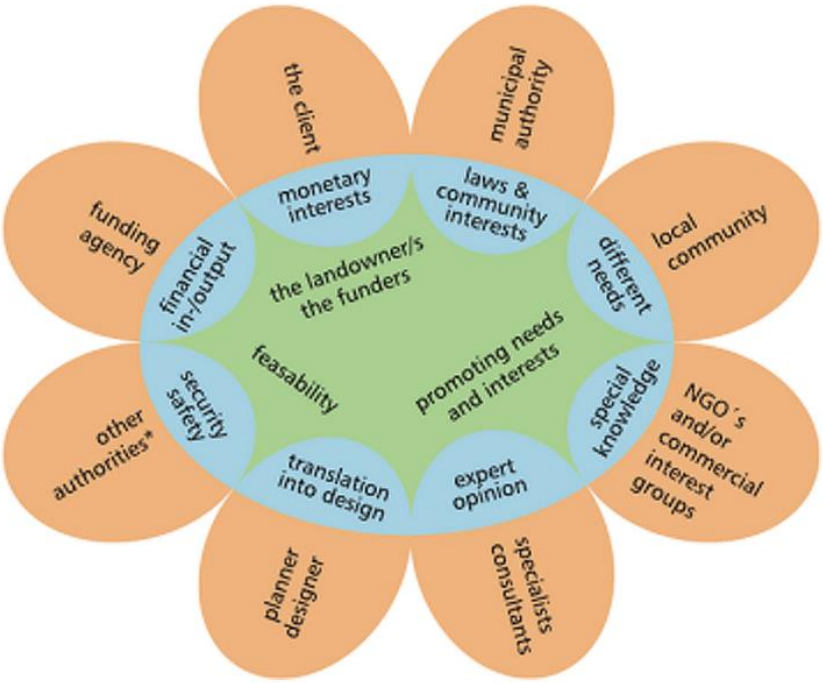

Figure 2 Main actors involved in an open space plan-making process (Stiles, 2012)

The complexity of participation lies in the diversity of the members; the more diverse the group, the more complex the participation process will be (Breman et al., 2008). It can result from the problems associated with the plan, which can directly affect the participation strategy and approach (Pleitje, 2008). Figure 3 illustrates a complex participation process through the increase in the volume of the cube.

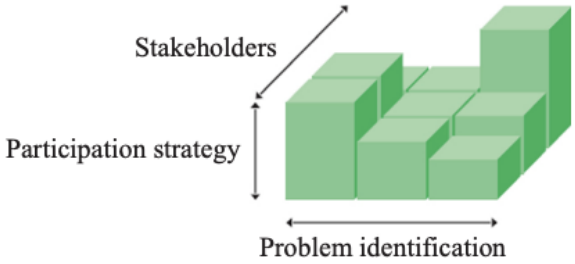

Figure 3 The participation cube (Source: Pleitje, 2008)

2.3.2. Level of Stakeholders' Involvement

The extent to which the relevant stakeholders will be involved in urban planning and their input impacts the decision-making structures are crucial factors that directly affect participation. The stakeholder involvement level can vary widely, but the higher the participation level, the more likely the plan will successfully meet the community's needs, as shown in Table 2. Greater participation means that the relevant stakeholders and the community members play a significant role in all phases of the process, including discussions with the planning authorities, policy formalization, solutions, and decision-making (Cilliers, 2014; Breman et al., 2008).

Table 2 Level of involvement of stakeholders in management roles (Cilliars, 2014)

Participation Level	Management Description	Roles		
		Style	Community	Authorities
None	No community participation	Closed	None	Sole control
Inform	Authorities give information; authorities determine the agenda for decision-making; no actual input from communities	Open	Receive information but cannot comment	Self-control, but giving information to the public
Consult	The community can comment; Authorities determine the agenda but consult communities concerning the development	Consultative	Consolidated meetings	Determine policy, but incorporate public view if needed
Advise	The community can give advice; authorities determine the agenda but are open to advise and suggestions from communities	Participatory	Advisor	Determine policy but open to solutions and suggestions
Cooperation	The community decides together with authorities; authorities, communities, and stakeholders collaborate in the decision-making process	Delegate, Facilitate	Decide together, equal rights	Management decides policy with predetermined objectives; policy in terms of equal rights
Equal rights	The community decides alone; final results are subject to equal preferences of the authorities and the communities	Facilitate	Initiative	Supportive to policy formalization via communities

The difference between regular and good participation lies in how the process is conducted and approached (Breman et al., 2008). Good participation promotes a sense of belonging among the stakeholders as they invest time and energy in the process. It creates a sense of ownership and builds social capital between stakeholders and planning authorities. Therefore, evaluation should be a core part of the participation process to determine the approach's effectiveness in achieving social inclusion. Evaluation helps identify whether the chosen method and approach were successful, if social capital was built, and if the public has benefited from the participatory planning process (Cilliers, 2014).

2.3.3. Level of Stakeholders' Enlightenment

The effectiveness of a participatory process depends on the level of stakeholders' enlightenment in the urban planning process (Ronoh et al., 2018). If the public does not understand what they are supposed to do during the urban planning process, they will not have the capacity to contribute effectively. Empowering the public through civic education on the need for public participation and how their contributions are needed to make an impact will encourage the public to participate in institutional projects. Most countries conduct participatory programs without enlightening stakeholders about the process (Shah, 2007); thus, stakeholders do not have enough information and the necessary documents to contribute. It may result in resistance by authorities to the participation of the poor and marginalized society. Urban planning projects can be too technical for the public to understand; therefore, with adequate enlightenment, stakeholders can prepare in advance and understand how the technical process works and how their contribution can positively affect it.

2.3.4. Political and Institutional Interests

The political and institutional interests influence the extent and quality of public participation in the urban process. Sisk (2001) highlighted that most urban planning authorities rarely give up control of the plan-making process since public participation is too often complex and time-consuming. They see themselves as experts and capable of controlling the participatory process. However, an expert-driven participatory process is seen to compromise the essence of public participation (Ronoh et al., 2018). It harms the participatory process because the public feels their inputs are not considered. The political leadership must facilitate a public-led plan-making approach to create an effective plan-making process since the leadership's interest in public participation plays vital role in its success (Andrews & Shah, 2005).

3. METHODS

This study employs a qualitative approach through observations, document studies, and interviews from real-world phenomena. It is adapted to discover underlying motives and to examine the decision-making' why and how, not just who, what, where, and when. Moreover, non-probability sampling was used in obtaining qualitative data for this research. The controlled selection of participants was not a critical factor because it was purposeful to capture the qualitative elements of the study.

The participants were selected based on their knowledge of the urban planning system and ability to supply information relevant to the research objectives. Semi-structured face-to-face interviews were used to capture the data, with the selected 33 participants from different sectors in the urban planning system, ranging across politicians, administrators, professionals, academia, developers, and civil society. This approach helped ensure a general representation of the overall stakeholders involved. Four politicians/legislators and ten local administrators from the urban planning authorities in the Abuja metropolitan area were determined. In addition, nineteen stakeholders from professionals from different sectors, developers, academics, and civil society involved in the plan-making process were elected (see Figure 4).

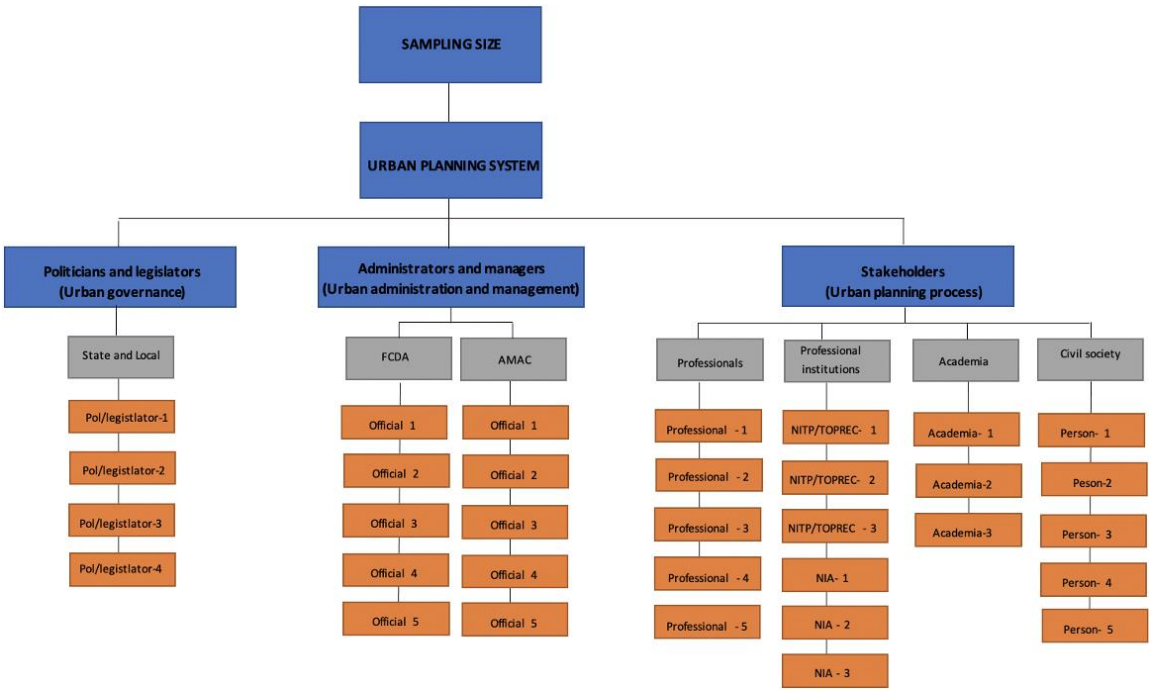

Figure 4 Diagram showing the non-probability sampling size for the research

The sampling framework included the creation of relevant respondent groups. It was intended that a reasonable number of respondents with a good knowledge of the research area would be chosen from each group. The smaller number of respondents in the civil society group reflected the limited number of private individuals or civil society groups who knew the research area and the Abuja plan-making process.

4. RESULTS AND DISCUSSION

4.1. The Importance of Participation in the Urban Planning Process

The respondents were asked to rate the importance of participation in urban planning, which is essential to understand to what extent the public value the participation in urban planning. Figure 5 shows that most respondents (87.5%) stated that participation is important. Only about 6% of the respondents considered participation to be slightly important or not at all important.

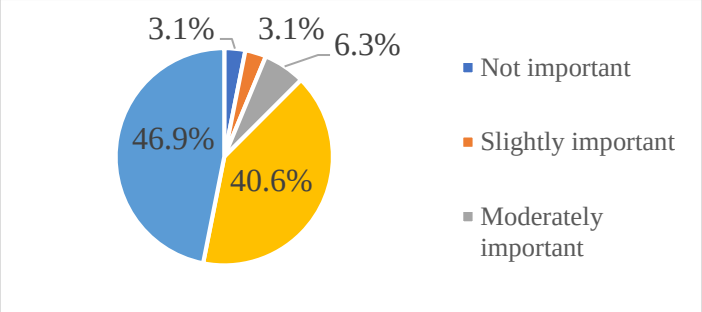

Figure 5 The importance of participation in the plan-making process from the stakeholders' perspective

This section discusses the opinion of various stakeholders on the importance of participation and factors affecting participation in the urban planning process, as summarized in Table 3.

Table 3 Importance of public participation in the urban planning process

Stakeholders	Importance of participation	Important factors considered during the planning process	Factors affecting participation in the urban planning process
Politicians	All agreed	• Public engagement • All-inclusive process (public and the different indigenous groups)	• Diversity of stakeholders
Administrators	Most agreed	• Inclusive process • People driven • Response to people's need	• Level of participation • Political will
Urban planning professionals	Most agreed	• All-inclusive process (public and the different indigenous groups) • Incorporate cultural, economic, and political factors in the urban planning process • In line with the lifestyle of the people. • Public interest-driven	• Diversity of stakeholders • Level of participation • Scope and context of the plan (Re-planning or new planning) • Public enlightenment
Academics	All agreed	• Public data-driven • Active participation (high level)	• Data-driven • Level of participation
Civil society	All agreed	• Inclusive process	• Diversity of stakeholders

4.1.1. Role of Participation in the Urban Planning Process from Politicians' Perspective

All the legislators and local politicians were of one view on the importance of participation in urban planning, suggesting that urban planning should be about people's engagement and entail an all-inclusive process that includes the public and the different indigenous groups in a particular area. They note that when these groups are engaged in the urban planning process, it gives a sense of belonging. One of the legislators raised concerns about withholding information from the public, which frequently occurs in an unjust society. He suggested that people feel excluded when important information concerning their environment is withheld. The legislators also noted the importance of involving the traditional rulers and locals in the community during the urban planning process to bridge society's culture, communication, and user needs gap. This will help make plans more socially acceptable to everyone.

4.1.2. Role of Participation in the Urban Planning Process from Administrators' Perspective

Most urban administrators and managers agreed on the importance of participation in urban planning to achieve an effective and successful plan. They highlighted that public participation in the urban planning process helps promote a sense of belonging and stresses the need to involve the public from the elementary stage to the implementation stage. This is because the people are the end-users, and it will not be successful if they do not identify and feel a sense of ownership with the plan.

The respondents from the administrators also suggested that the urban planning process should be people-driven since the public is on the ground and can help identify critical urban issues facing their community. Furthermore, people can also describe the plan's implications in their lives. This participatory process will enable the government to develop effective strategies that satisfy public demand during urban planning because they are well informed. They bolstered that the urban planning process should respond to people's needs and not to what the government thinks they need. This is because, when the public is fully engaged, they are inclined to inform the government of what they need. This will help the government and those in authority plan according to the actual needs.

An administrator shared his concerns about participation in the urban planning process using two questions. First, what is the level of public involvement in the plan-making process? Second, do those in authority have the political will to enforce a participatory approach in the plan-making process? he suggested that, despite public participation being a statutory policy in the study area, the urban planning process is mainly driven by those in authority. Public involvement is dependent on the political will of those in authority to implement the policy was also argued. However, few respondents argued that the effectiveness of participation depends on the political willingness of the authority to implement such an approach.

> *We are supposed to involve them in the process; now, what is the degree of involvement? The policy has always been there always to include people, but we discovered that their participation is shallow. The policy can be there, but not the political influence or will to enforce it*. (Respondent 8)

4.1.3 Role of Participation in the Urban Planning Process from Professionals' Perspective

Most urban planning professionals and organizations view participation in urban planning as necessary to achieve an effective plan. However, one of the respondents had a different view by noting that participation in the urban planning process is highly dependent on the scope and context of the plan. The majority highlighted that the public is the primary stakeholder in the

urban planning process, and it is essential to be informed about how the plan affects them culturally, economically, and politically. They argued that most urban planning systems in developing countries are usually ineffective because of their inability to incorporate these factors in the plan-making process.

Some of the urban planning professionals noted the effect of inadequate planning in the Gibi andApo resettlement schemes in the study area, where the developments were not in congruence with the lifestyle of the proposed dwellers. This project was termed unsuccessful. Most of the proposed dwellers sold their houses to others and refused to relocate there because it did not fit their way of life. The respondents indicated that it resulted from the indigenes' and proposed dwellers' lack of involvement in the resettlement planning. Urban planning professionals also argued that there is a difference between having a good and effective plan. They suggested that an effective plan is one that the government plans with the people by involving them and considering their interests first. Public needs will not be incorporated into the plan-making process when the plan is developed in isolation.

One of the respondents points out that some available policies and tools promote public participation in the urban planning process of the Abuja urban planning system. However, the major challenge is the political will to implement such policies. Therefore, the public must be enlightened before participating in the plan-making process to contribute effectively because the public can understand the plan through an efficient enlightenment process. They can inform the authority regarding the plans' impact on their culture, way of life, and economy.

> *For us, policies are not usually the problem or the tools, but the political will to carry them out is.* (Respondent 17)

> *If you want to plan, and you want public participation, you should, first, enlighten them and let them know what it is all about*. (Respondent 17)

One of the respondents, contrary to the majority, argued that participation is not important in a new planning process but important in the re-planning process since it is a different process. When planning a new area, there are no existing dwellers; hence, public participation is not important. However, the respondent strongly supported the need for participation, especially in re-planning an existing area where people have developed a particular way of life. He argues that the re-planning process is an urban renewal process that should involve the area's inhabitants to understand their needs and how it affects their community.

> *When discussing public participation, you are talking about the re-planning process. You are looking at an existing urban settlement you want to make better. That is where you have people living there who have already developed a particular lifestyle. Then you want to improve the living standard and the physical environment. That is when participation comes into play. Then you have people there who will discuss how things are working and how to improve that. We need to get that clear. In the social planning aspect, you need people who are already there. It is more than an upgrade; it is an urban renewal process more than a first-time planning process. There is a difference.* (Respondent 19)

4.1.4. Role of Participation in the Urban Planning Process from Academics' Perspective

Academic scholars have made a strong case for public participation in urban planning. They noted that one of the significant challenges with urban planning in developing countries is the lack of data from the public. The respondents reported that the data used in the plan-making process must emanate from the local public for planning to succeed. It was also noted that the society is alien to the people because the data used in the urban planning process does not originate from the

local community, owing to most urban planning concepts being imported from advanced and prosperous economies.

One of the respondents also stated that most of the current urban planning processes take a consultative approach rather than an active participatory approach. Active public participation is when people are involved in the plan-making process and are allowed to make their inputs into the conceptual stage, planning, design, and implementation stage. In contrast, the consultation process does not allow the public to give input in the decision-making process.

> *Public participation is not public consultation. There is a difference between public participation and consultation. Participation means that the people will be involved right from the initial conceptual stage of the planning, all through the planning stage, design stage, and implementation. And that is what is called public participation. So, participation should involve the people right from the start, involving the people, research with them, and allow them to make their inputs with which they can design their environment.* (Respondent 27)

4.1.5. Role of Participation in the Urban Planning Process from Civil Society's Perspective

All the respondents from the civil society inquired about a more inclusive participatory approach to the urban planning process because the public should be fully involved in urban planning through different participatory techniques enabling their opinions to be heard. These techniques will also assist those in authority in looking at other views objectively and forming a better plan. This platform, where the public and professional planners share vital information, provides a context for solving urban challenges.

> *They must involve the public so that the public can give their opinion. I am not saying they should take the public's opinion, but they should hear from them, weigh sides, and decide which option is the best so we can get the perfect planning process for the city. They should make policies that involve people in the planning process through town hall meetings. Get people together and give them a plan of what they want to do. And they look at it critically, offer their own opinions, and devise a better plan.*

4.2. The Importance of Participation in the Urban Planning Process

The literature and good practice show that participation is important in any successful urban planning system (Healey, 2006; Hall & Tewdwr-Jones, 2011; UN-Habitat, 2007). It was supported by the majority of the respondent from this study. This section discusses the different benefits of participation in the urban planning process.

4.2.1. Participation in Urban Planning Helps Create Effective and Successful Plans

Participation in urban planning increases plan efficiency and offers better chances for developing solutions that are sustainable and feasible in any urban planning system (UN-Habitat, 2007; Brodie et al., 2009; Innes & Booher, 2018; Healey, 2006). The literature highlights that a successful plan highly depends on how effective the participatory process is. When people are directly involved, it not only ensures the effectiveness of the urban planning process but also helps improve the quality of the urban planning outcomes (Kelly, 2010; Hopkins, 2001). Kelly (2010) highlighted that the participation of diverse stakeholders should be encouraged because it increases the sample from which a solution can be drawn. However, the literature shows that an increase in stakeholder size in the urban planning process may be at the cost of interaction and distraction (Hopkins, 2001).

There is broad agreement that the public's involvement in urban planning enhances the efficiency of the urban planning system and enables people to take control of their lives without those in authority imposing it (Cornwall, 2008; Healey, 2006; Cilliars, 2014). It contradicts Hopkins (2001), who argued that the prescription for extensive public participation as a guideline in urban planning does not ensure efficient planning. Instead, the participatory process should be flexible and combine all the formal and informal democratic institutions in deliberations to achieve an efficient plan.

This viewpoint was supported by some academics interviewed in this study. They felt that most urban areas are becoming alien to the people because the urban planning systems and the plans do not relate to them. The respondents argued that importing urban planning concepts from established or successful urban planning systems will not solve society's urban challenges. They highlighted that generating data from the local population during the urban planning process must fit with the urban planning system and the users' way of life. This is because ideas that fit the local environment pattern and indigenous lifestyle can only be achieved when the locals are involved in urban planning.

4.2.2. Participation in Urban Planning Encourages Participation and collaboration

The literature shows that effective public participation in the urban planning process encourages greater engagement of different stakeholders, thereby strengthening the results' quality and comprehensiveness as well as the process's outputs (Hopkins, 2001; Breman et al., 2008; Kelly, 2010; Cilliers, 2014). The literature also shows that the actual involvement of a community in urban planning helps foster community development, with a focus on building relationships and service delivery, holding potential for more inclusive transformations (Della Porta & Diani, 2006).

Most respondents from the qualitative analysis hold the same view. They noted that people engage with urban planning activities when their involvement and opinions are valued. They also perceived public participation in urban planning as helping establish strong communication between urban planning institutions and key interest groups. It will not only help to build social capital between them but also enhance trust. When the locals participate as stakeholders in the consultation stage of the urban planning process, they tend to be more willing to collaborate when the government wants to develop the community's urban plans. However, they are reluctant to participate or comply with government intervention when they are not involved.

It is clear from the findings that plans should not be developed without engaging the end-users and their representatives; hence, the platform for them to participate should be provided. The respondents noted that public participation could be achieved by enhancing strong synergies and a communicative link between the locals and traditional rulers, bridging the user-need gap in most cities in developing countries. It will foster better communication and interface between the government and the socially excluded in society and help to develop socially acceptable plans that meet the community's needs.

4.2.3. Participation in Urban Planning Helps Identify and Solve Urban Issues

Both the theory and good practice indicate that the challenges facing most communities today, such as urban sprawl, urban decay, and social vices, are the results of ineffective planning and lack of participation in the plan-making process. (Amba, 2010; UNECE, 2013; Arcadis, 2016; UN-Habitat, 2007). The literature shows that participation can be a crucial strategy for those in authority and civil societies to solve urban problems (Taralunga, 2010). It strengthens the public institutions' democratic credibility and helps proffer solutions satisfying public demands by

identifying critical urban issues, establishing priorities, and mobilizing adequate resources to meet the needs. The literature also shows that participation can be a valuable tool for identifying the problems and assessing strengths, weaknesses, opportunities, and constraints (Kelly, 2010; ICPS, 2002).

The findings of this study also denoted that encouraging the participation of relevant stakeholders and political actors can help identify major urban problems, detect causes and consequences, embrace diverse solutions, and construct suitable responses. In the case study, most approaches to urban planning since the early 2000s have been dependent on public-private partnership (PPP) initiatives allowing local inhabitants, businesses, and groups to be involved in urban planning, yielding benefits in identifying strengths, weaknesses, opportunities, and constraints.

As highlighted in the findings, public participation assists in understanding urban challenges. The relevant people can inform the planning authority of the challenges to be used in urban planning. This will not only help solve urban problems but also help create an understanding of the reasons behind such challenges.

4.2.4. Participation in Urban Planning Promotes Acceptance and the Sense of Belonging

Participation promotes a sense of belonging among the different stakeholders in urban planning. Investing their time and energy in the plan inevitably leads to accepting, promoting, and defending it (Cilliers, 2014; Kelly, 2010). Public participation in urban planning should not be restricted to a particular group. Still, it should be open to all interested groups so that all views, inputs, and priorities are considered, creating a sense of community and belonging among the different groups (Kelly, 2010). UN-Habitat (2009) expanded this by noting that inviting the public to engage in urban planning is considered an acceptance sign by the government from the public's perspective.

This was corroborated by the study's findings that illustrated people want to feel included, be heard, and be given a chance to express their opinions, regardless of the outcomes. This was emphasized, in particular, by those who participated in the interview process. Most respondents highlighted that urban planning institutions and those in authority should ensure that the public participates and inputs in urban planning. They suggested that a sense of ownership developed when the public is involved in the urban planning process can foster a cooperative agreement on chosen actions and help reduce resistance.

4.2.5. Participation in Urban Planning Promotes Public Empowerment and Enlightenment

The literature shows that public participation in the urban planning process helps empower and enlighten the public about the state of their communities (Brodie et al., 2009; Hopkins, 2001; Kelly, 2010). When the public is involved in urban planning, they will be better educated about the process. Also, there is a greater likelihood that their contribution will make the plan successful. Elkin (1987) noted that participation helps define the public view and gives them confidence in what they know and have experienced. Moreover, Reardon (1998) stated that participation increases the power of the weak in society to augment the cognitive basis for initiatives beyond the ability of urban planners.

Most respondents of this study supported the literature, where they saw participation as an essential tool to empower and enlighten the public. It was observed that most people in the study area are ignorant of the urban planning processes and policies. The respondents highlighted that these areas' education and awareness could be achieved through participation. The respondents argued that participation without enlightenment makes a mockery of the urban planning process since the public cannot understand the plan and its impact on their culture or economy.

Furthermore, participation can also stimulate social and organizational learning and provide a process for enhancing stakeholders' understanding of how a complex urban system function. It is essential because when the public knows and understands the urban planning process and the impact of the proposed plan on their society, they will be able to participate effectively.

4.2.6. Participation in Urban Planning Ensures Effective Plan Implementation and Management

The literature indicates that when different stakeholders are involved in planning and developing plans with planning authorities, the plan is most likely to be implemented (Quick & Bryson, 2016). Through public participation, stakeholders can interact with government agencies, political decision-makers, third-level institutions, non-profit organizations, and business organizations to develop, create and implement inclusive policies, plans, and programs.

The findings show that implementing the plan is likely tricky when the public is not part of the process. According to some respondents, when the public is part of the framing and development of the planning order focusing on decisions they expect to make, they feel included. This increases the likelihood that the plan will be implemented and well managed by the public. In some cases, the urban planning professionals and administrators in the study area's development plans are without the public's input. It is based on their views that they have sufficient professional skills and knowledge to know what is needed and to provide it. The findings show that most of these plans have not been effective due to the lack of public participation. The findings of this study supported the general view in the literature that a process involving only the professionals and the urban planning authorities will not answer important cultural, social, and economic questions. Furthermore, it will make any plan challenging to implement.

4.3. Factors Affecting Effective Participation in the Urban Planning Process

4.3.1. Stakeholders' Diversity Influences Effective Participation in Urban Planning

The literature indicates that most participatory processes worldwide focus on large numbers of public participants (Hopkins, 2001; Kelly, 2010). However, the success of any plan will depend on the stakeholders' diversity (Cilliers, 2014). Previous studies show that the stakeholders involved in the urban planning process should be selected objectively and cover a diverse range of sectors and socio-economic groups since more diverse stakeholders bring better input and output (Hopkins, 2001; Kelly, 2010; Cilliers, 2014). Since more varied stakeholders also mean a more complex and complicated participatory process (Pleitje, 2008), selecting stakeholders should emphasize representation and meaningful citizen participation (Kelly, 2010).

The findings confirmed the view that the effectiveness of the participatory process lies in the diversity of the stakeholders. Most respondents argued that relevant stakeholders' participation in urban planning should not only be based on quantity but also ensure that local indigenes, professionals, and the vulnerable are part of the decision-making at various stages of the process. Some respondents noted, for example, that the Apo resettlement program in the study area was unsuccessful because the indigenes were not involved in the planning process. Understanding the interests of multiple actors and involving them in urban planning is key to making the plan effective and inclusive.

4.3.2. Stakeholders' Involvement Level Influences Effective Participation in Urban Planning

The literature shows that the success of a development plan will depend on the stakeholders' level of involvement in urban planning, which directly impacts the plan's quality and thoroughness (Breman et al., 2008; Cilliers, 2014). The approach is significantly more practical when the public

voluntarily takes control of the urban planning process to influence a decision involving meaningful choices about their community (ICPS, 2002; Parry et al., 1992).

The study area's findings align with the literature, which believes that urban planning should be people-centered and employ a bottom-up approach. This public-led approach enabled the public to engage with the project as their own and then manage it effectively. Furthermore, the participatory process should not be limited to the plan preparation stage; it has to be employed at every level to achieve fairness and inclusiveness. The research shows that when the public engages from the plan inception to the implementation stage, it increases efficiency and ensures that the planned output works for everyone.

4.3.3. Stakeholders' Enlightenment Influences Effective Participation in Urban Planning

The literature and good practice show that participation without enlightenment can make the process ineffective because the public may not have the knowledge and skills to contribute effectively (Hopkins, 2001; Kelly, 2010); thus, the public should be adequately informed about the urban planning process (Ronoh et al., 2018).

The interviewed respondents support this assertion, agreeing that the public needs to be enlightened before they can effectively participate. It was also the view of the respondents that awareness and education should be carried out at the grass-roots level, cutting across different gender, socio-economic groups, and cultural leanings. It was suggested that this might involve engagement with local and traditional heads who understand the local way of life rather than the professionals in the local and planning authorities.

The findings show that engaging with local community heads and indigenes ensures a successful plan. This is because the local community heads and leaders understand their people's plights and can effectively communicate with their community's members. Their involvement will enlighten and encourage society members to participate in urban planning.

4.3.4. Political Interest in Participation Influences Effective Participation in Urban Planning

The literature establishes that effective urban governance can influence high-quality Multi-Stakeholder Engagement and Communication (MSEC) in urban planning (Hemmati & Rogers, 2015). To create an effective process, the political leadership must facilitate citizen empowerment through a rights-based and bottom-up plan-making approach (Andrews & Shah, 2005). It has a practical and transformative urban planning process that promotes the participation of the necessary stakeholder groups in developing and creating strategies and plans that meet the plan's objectives (Hemmati & Rogers, 2015). It was also seen that the lack of political and institutional interest in participation harms the participatory process by reducing the participant's level of interest.

It was observed from the findings that the opinions of the urban planning administrators and professionals on the political influence of participation in urban planning reflect the literature. They considered that effective political governance and leadership determine the success of a participatory process. They argued that good leadership integrates diverse perspectives, views, and expectations from different stakeholder groups in urban planning. It ensures different opinions are heard, and the needs of everyone in society are met. However, some respondents noted that the public is usually not involved in most urban planning and spoke of how the lack of effective political leadership can deter the public's participation in urban planning. The findings also show that the participatory process is ineffective if there is no political will from those in leadership to implement the plan.

5. CONCLUSION

Generally, this paper supports the idea that urban planning should not be carried out without considering the needs of the public first since the participation of the public and the major stakeholders in the urban planning system helps create effective and successful plans; encourages collaboration; helps identify and solve urban issues; promotes acceptance and a sense of belonging; promotes public empowerment and enlightenment and ensures effective plan implementation and management.

However, the research demonstrates that the diversity of stakeholders, the level of stakeholder involvement, the level of stakeholder enlightenment, and the political interest of leadership in participation can affect the effectiveness of participation. The findings also suggest that participation is not meant to address and solve all urban problems, given its wide range of challenges, but is of particular importance in giving the underprivileged in society a platform to air their views and opinions.

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A THEMATIC LITERATURE REVIEW ON THE IMPACT OF COVID-19 PANDEMIC ON INDIAN REAL ESTATE

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ABSTRACT

The COVID-19 pandemic has impacted the world badly. Almost all activities were suspended, and thus it severely impacted the economy, including the real estate sector. This ongoing pandemic has pushed the sentiments of the sector to their all-time lowest. This research aims to analyze the influence of the COVID-19 pandemic on the real estate industry in India, as well as to determine the most impacted segments. Report achives from eminent property consultants including Knight Frank, Coldwell Banker Richard Ellis (CBRE), and Cushman & Wakefield were reviewed in this study. The qualitative analysis done to the reports and literature shows that both the residential and commercial segments have been impacted badly. However, the residential market has recovered to its pre-COVID level after the first lockdown. Meanwhile, in the case of the commercial market, the pandemic led to many innovations in the office segment, such as hybrid working, portfolio growth, and the hotelization of office spaces. Such innovations were also found in the retail segment, such as reinventing the experience, use of new-age technology, omnichannel strategy, realigning the retail formats, and so forth. Hence, they have boosted these segments and accelerated the recovery. Amongst all the segments, the hospitality segment was the worst-hit segment. It was the first to fall and is last to rise. Due to the fear of getting infected and travel restrictions, tourism has effectively stopped, and this has greatly impacted the hotel segment.

Keywords: COVID-19; Pandemic; India; Real Estate Sector

1. INTRODUCTION

The upsurge of Coronavirus disease (COVID-19) has hit the world badly. Almost all activities were suspended. Thus, it brings severe consequences since it has been spread all over the world. It made many countries experience a phase of economic slowdown and recession, including India (NDTV, 2020). Amongst all, the real estate sector has been the worst-hit sector. Ongoing economic slowdown, liquidity issues, non-banking financial companies' crises, previous policy measures. Furthermore, reforms such as demonetization, the Goods and Services Tax (GST), and the Real Estate and Regulatory Authority (RERA), were supposed to promote the expansion and growth of the real estate sector. However these initiatives were ineffective (Bhoj, 2020). For this reason, this paper primarily aims to investigate the influence of COVID-19 spread on the real estate industry of India and highlight the crest and troughs in the entire real estate segment during this period.

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Cholera in 1817, Plague in 1896, Spanish flu in 1918 have caused disruptions all over the world, causing demand and prices to decline in the severely impacted areas (Francke & Korevaar, 2021). In general, assessing the epidemics in the short and long term is challenging despite some points being common. Every pandemic is different in its way, has its own life, its characteristics, and its cause. The COVID-19 pandemic is the worst-hit pandemic since the Spanish flu that happened a century ago (Acharjee, 2020).

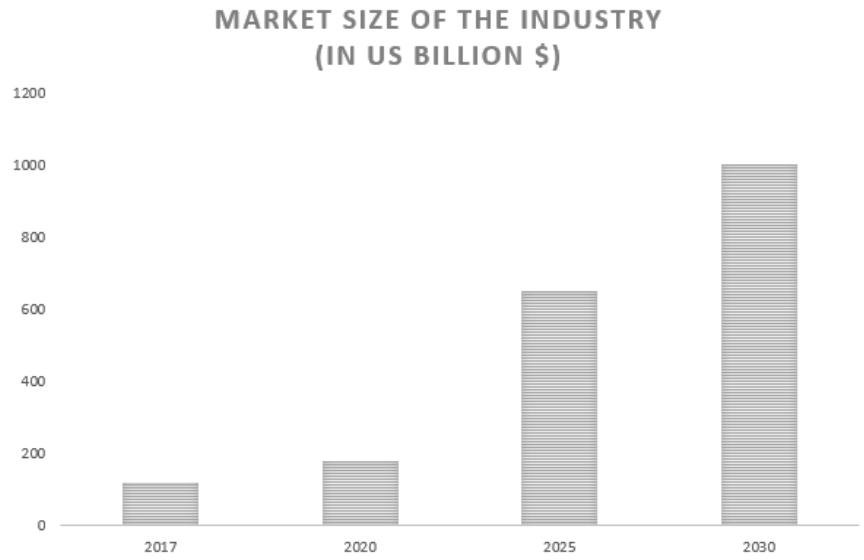

Figure 1 Projected growth in the real estate industry's market size (CBRE Research, 2021b)

By 2025, Indian real estate sector is expected to contribute 13% of the country's gross domestic product (GDP) (IBEF, 2021). Currently, as per growth projections by Coldwell Banker Richard Ellis (CBRE), the GDP contribution of the real estate sector in 2021 is 9.1% from 7.4% in 2020 (CBRE Research, 2021b). While Reserve Bank of India (RBI) has projected India's growth in Q3 and Q4 of FY21 with the contradiction of 7.5%, the full fiscal year (FY) is expected to increase by roughly 9% in FY 2022 (Knight Frank, 2020b). The market of real estate has demonstrated flexibility in the face of a COVID-induced recession, with a robust K-shaped rebound expected in 2021. As can be seen in Figure 1, the growth is projected on a rapid growth trajectory, with a goal of reaching US $1 trillion by 2030 (IBEF Knowledge Centre, 2021).

After agriculture, Indian real estate sector is the second largest source to employment, directly employing 16% of the entire workforce in India. In 2017, 52 million people were employed, with 67 million were predicted to be employed by 2022. With 28.84% growth in five years, it currently appears challenging to attain post covid as the construction industry has encountered a labour shortage and job losses due to liquidity constraints. (Bhoj, 2020).

Property transactions were on hold in the first lockdown which was imposed from March 2020 to June 2020. The Indian economy began to recover from the first wave, only to be devastated by the new wave in March 2021. The new wave was more lethal, but it was more localised and less limiting. As a result, the direct economic impact was less severe, but the harm to health and life was significant, resulting in profound scaring of consumer emotions, which delayed the rebound till 2022 (Chauhan, 2021).

Due to COVID, the unusual year of 2020 experienced massive demand destruction, unpredictability, and uncertainty, followed by long-term doubts about the epidemic as 2021 rolled on. According to the record of other nations, there is a risk of additional waves of COVID. Nevertheless, with the infection incidence in India is decreasing and vaccinations are on the horizon, the worst appears to be behind us. 2021 could be the year of caution, with a resurgence in business and financial activity in second half (H2) of 2021. This is so when the impact of the coming third wave is minimal, if it occurs at all (Knight Frank, 2020b). The residential market will remain steady as a result, while changes in the commercial sector will accelerate. The impact of COVID-19 pandemic on the real estate sector in India is illustrated in Figure 2.

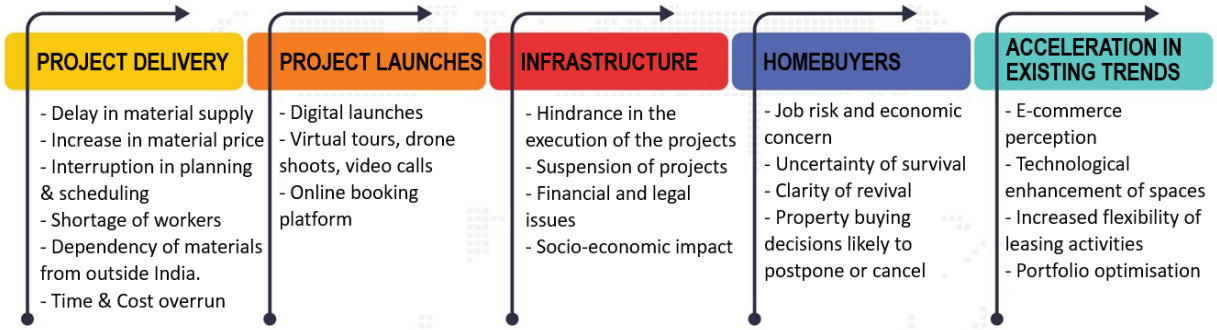

Figure 2 Identified impacts of COVID-19 pandemic on real estate sector

2. PROPERTY IN INDIA AND THE IMPACTS OF COVID-19 PANDEMICS

The journey of property sector in the India is full of ups and downs. Real estate has never been hit hard since the economic slowdown took the global financial crisis back in 2008. The 2008 financial crisis had long roots. The causes of this catastrophe are numerous and diverse. A few examples are a housing market boom, rumor, high-risk mortgage lending, their practices, tax laws, etc. Although it all started in the United States, the effect was contagious to the Indian economy, despite being at a different level. In real estate, the global economic recession caused a significant drop in demand for Indian real estate. The recession has compelled real estate investors to scale back their expansion plans. Ongoing projects have been impacted due to a lack of capital both from the banks and buyers (Francke & Korevaar, 2021). From the 2008 crisis until 2015, there was a search for buyers within the real estate sector. Many builders were unable to meet expectations in 2015, resulting in a drop in property transactions.

However, in 2015, there was a rise in demand due to the government scheme “Housing for all by 2022", aiming at providing affordable housing for the urban poor by 2022. Nevertheless, demonetization in 2016 was received with a lot of panics, pushing the demand downward to 40% again. The effect varied depending on location, but there was a progressive increase, particularly within the affordable housing category. RERA, which will increase investment in the housing market and improve transparency for purchasers, would further reduce demand (NDTV, 2020). The adoption of a new tax system of GST to cut multiple taxes increased the profit margin for developers. However, it has also increased the cost of construction materials and decreased the demand with the increased cost of construction. While the real sector remained struggling to grow, the COVID-19 pandemic hit. The pandemic once again gave momentum toward the downfall in the second quarter (Q2) of 2020. Luckily, with the slogan given by the Prime Minister Mr. Narendra Modi “Stay home, stay safe,” people have realized the importance of home and created a demand again in the H2 2020, while the lockdown was relaxed. The second wave hit the worst falling demand again, but the residential market has

proved to be robust in the first half (H1) of 2021 and has coped up more than its pre-COVID after the relaxation in the lockdown of the second wave (Knight Frank, 2020c).

The year 2020 showed the reflections of both disturbances associated with the COVID-19 pandemic in H1 2020 and recovery in H2 2020. In recent years, many technologies have been developed to help businesses improve their resilience, sustain stability, and assure business and real estate sustainability. The collaborative path through the COVID-19 pandemic was characterized by the realization that corporate operations would never be the same again. The residential market was healthy during H1 2021 despite being impacted so severely during the pandemic. Meanwhile, commercial real estate will continue to be in high demand due to issues such as the psychological influence on employees, data security, and measuring productivity (Knight Frank, 2020a). The subsections below discussed about each the growth of property sector and how the pandemic impacted it.

2.1. Residential Sector

COVID is most likely to disturb the expected growth momentum of residential sales in the affordable and non-affordable housing segment in 2020. Developers were already facing the problems of liquidity crises and low demand with the introduction of government reforms. It then got worse when the COVID-19 hit since it affected the new project launches and completion of ongoing projects (Uma & Gujar, 2020).

The pandemic has made people realize the importance of homeownership. As human mobility was restricted and people stayed indoors for 15 months, the perceived value of one's home ultimately pushed the sales. The government initiated several supportive measures, such as a reduction in repo rates, low mortgage rates, and stamp duty reduction in some cities like Maharashtra and Karnataka, along with incentives. These efforts aimed to support the consumers whose primary challenge was to pay the Equated Monthly Instalment (EMI) during the lockdown (Uma & Gujar, 2020). These are the primary drivers for the increase in sales during Q3 2020, which saw a recovery of 84% quarterly (CBRE Research, 2021a). Per Knight Frank's report, the affordability matrix has improved a lot, which has also pushed the market along with the government and central bank's encouragement (Knight Frank, 2020b). For real estate, the government has raised the threshold limit of the Insolvency and Bankruptcy Code in 2016 (IBC). The government has assured the developers that deadlines will be extended under the Force Majeure provision of RERA (Uma & Gujar, 2020).

Table 1 Affordability Index (EMI to Income ratio)
Source: Knight Frank (2020b)

City	2010	2015	2020
Mumbai	93%	94%	61%
NCR	53%	51%	38%
Bengaluru	48%	48%	28%
Pune	39%	38%	26%
Chennai	51%	43%	26%
Hyderabad	47%	39%	31%
Kolkata	45%	44%	30%
Ahmedabad	46%	36%	24%

Mid-end (4.5 million to 10 million) and affordable (less than 450 million) segments have continued driving sales in the residential market, which accounts for 80% of total housing sales.

They are expected to dominate sales in coming years as well. Developers are focusing more on completing projects such as ready-to-move-in flats and smarter and eco-friendly homes as they are reaping the benefits of pent-up demand and festive demand (CBRE Research, 2021a).

2.2. Commercial Sector

2.2.1. Office Segment

The COVID pandemic has moved the commercial sector upside down, particularly the office segment. Traditional office working systems have now transformed to work from home or remote office systems because of the lockdown imposed. COVID has induced the system of WFH and forced the company to make arrangements for the same. However, this system has its pros and cons. People have achieved better flexibility and enjoyed a better time with their families. However, it also has several concerns, such as productivity, lack of adequate home infrastructure, mental and physical health issues, disconnection with corporate culture, fewer opportunities to learn, and a sense of isolation which specifically is felt by the young and new employees, (Knight Frank, 2021). With things returning to normal, senior business leaders believe that employees should work from the office, offering greater flexibility and choice (CBRE Research, 2021a). However, as per the Knight Frank research only 20% of respondents were convinced that organizational performance and productivity in the employees are increased. 50% of the respondents believed there is no change, while the other 30% believed that productivity and performance have deteriorated slightly (Knight Frank, 2021). The World Economic Forum (WEF) surveyed the working habits of the employees post-pandemic. Similarly, the results showed that 47% of employees working in the office regularly before the pandemic wanted to work remotely for at least a day to 4 days a week. Then, 35% of employees wished to work completely from the office, and the remaining employees enjoy their work from home (World Economic Forum, 2021). This change indicated hybrid work as a new norm (see Figure 3). With this, CBRE expected an increase in office portfolio in the long term and has indicated a limited downside impact on future office demand (CBRE Research, 2021a). The importance of the office has shifted from a place of management to a place of engagement and inspiration, which is more effective in terms of supporting collaboration, the productivity of the team, employee learning and development, and innovation relative to hybrid working (Katsikakis et al., 2020).

Cushman & Wakefield believed that five dynamics, namely, “productivity/output, innovation/creativity, company culture and branding, employee satisfaction/retention, and location and building strategy,” will influence the extent to which remote work will affect the office segment in a post-COVID era (Brown et al., 2020).

There are some strategies to shift from a ‘traditional’ to a ‘hybrid’ office environment, such as:

1. Portfolio growth and optimization via the right kind of mix of traditional flexible space as well as remote working strategies is the top solution to recalibrate the way we investigate office trends in mere future. Strategies for the workplace involve amenities and services to meet changing employee needs, repositioning the spaces, and enhancing technological tools to transfer the way commercial properties are designed and marketed. The strategies offer flexible spaces and layout changes that evolve to meet the ever-changing occupier requirements (CBRE, 2021). Strategies related to Work from Home (WFH) and workplace flexibility is not a fit for all argument. Offices should take an integrated approach while optimizing workplace options. With a variety of options and the change in working patterns, the workplace will define as a network of different locations and experiences. This broadly depends on the factors such as age, seniority, department, company size, and

geography (Brown et al., 2020). However, this new network will have a substantial impact on our working style, portfolio footprint, and the technology that will be in support of this (Mohanty, 2020).

2. Companies are creating more varied portfolios by establishing satellite offices, shifting to decentralized locations, or implementing a hub-and-spoke strategy for growing workforce agility, enabling them to choose where to work on any given day. Employee productivity, environmental, social, and corporate governance, health, and wellness are likely to be at the forefront for the companies. Emphasis on high staff-to-desk sharing ratios is given. In the past, every office provides one desk for one person. Now, it has been reduced the desk occupancy to accommodate the new norm of social distancing, which has given rise to privacy concerns, floorplate efficiency, and infrastructure issues (CBRE, 2021).

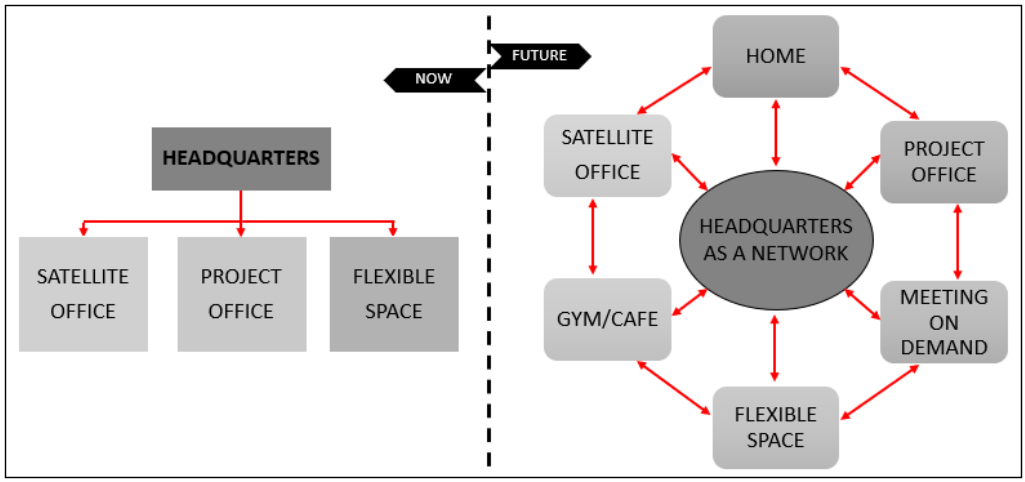

Figure 3 Hybrid Workforce Network
Illustrated by authors, adapted from CBRE Research (2021a)

2.2.2. Retail Segment

Over the past few years, the performance of shopping malls has declined. Vacancy levels have risen, which has created a funding problem for small developers. Nevertheless, the strong pan India developers have a greater reputation in terms of managing project quality, such as DLF, Inorbit, and Phoenix, and have taken the lead in Grade-A mall projects. Grade-A malls have demonstrated higher growth rates compared to stable office assets (Thomas, 2021).

A total of 54 malls were predicted to be launched. However, as the pandemic started hitting, only five malls eventually started their operation in some leading cities of India like Gurugram, Delhi, Bangalore, and Lucknow. This showed how adversely the retail segment has been impacted because of COVID. Fear of the virus spreading during the initial stage of COVID has reduced the footfall of malls. It happened even before the government declared the lockdown. The footfall has been reduced to approximately 55-60% across India. As per the survey by the Retail Association of India (RAI), relaxation in the lockdown did not impact the retail segment as the fear of getting infected is still there (Mishra, 2021).

On the other hand, the COVID-19 pandemic has made people realize that a lot can be accomplished within the comfort of our own homes. E-commerce, for example, played an important role during the pandemic, as it is an acceleration in already existing trends and a sustainable shopping experience for customers. India ranked fourth globally in terms of e-commerce potential in 2020. Though e-commerce was a reason behind the adverse impact on

mall performance, it came to the rescue during COVID pandemic. The e-retail is a new norm in the shopping behavior of consumers. Mall owners now focus more on creating a positive consumer experience by enhancing the quality of air, cleanliness, sanitization, and raising awareness. In the next few years, shopping malls are likely to evolve into locations where wholesome, superior consumer experiences are prioritized (see Figure 4). They will no longer only be shopping malls but with fine dining, events, and entertainment centers. Such places will provide enhanced social interaction (Thomas, 2021).

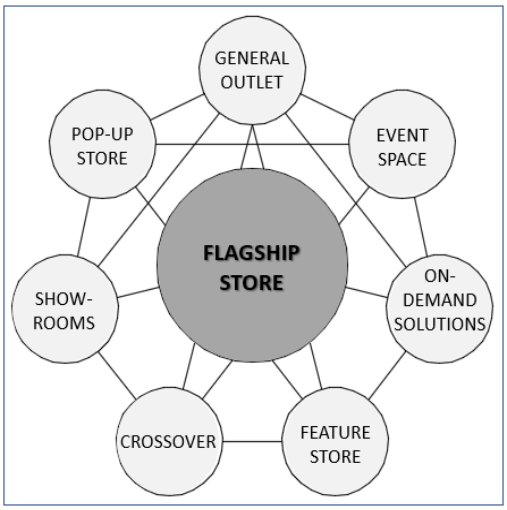

Figure 4 Future of retail stores (CBRE Research, 2021a)

Some strategies can be employed to boost the retail market in the post-COVID times, for example:

1. Emphasis is given to reinventing the experience and realignment of retail formats and configuration as post-COVID. Stores are also expected to serve as platforms to engage consumers and amplify their brand. This will require a thorough re-evaluation of retail properties' location, design, and operation and timely adoption of an omnichannel strategy with physical experience. With rental incomes, we should also consider other sources of revenue, such as increased in-mall advertising, sponsorships, and even live-streaming events (CBRE Research, 2021a).
2. New-age technologies such as AI and AR are to be an integral part of mall owners' business strategies with greater attention to the health and safety of visitors post-COVID. The adoption of digital marketing, targeted promotions, predictive analytics, and in-store automation will provide a competitive edge (Thomas, 2021).

2.2.3. Hospitality Segment

The hospitality sector is the worst-hit sector of all and has seen an all-time low demand. Puneet Chatwal, Chief Executive Officer of Indian Hotels Co. Ltd., said, *"the sector has never experienced such a decline in revenue in the last 100 years"*. Lower wages and employment insecurity make customers more worried about their fundamental requirements. Living a luxurious life and traveling is no longer a priority, which has impacted the hospitality industry most (Kakkar et al., 2020). In addition, movement restrictions over and across the world are another reason for the impact.

The impact is huge and still cannot be predicted on both the supply and demand sides. A challenging situation is faced limiting the demand side (freedom of infection and fear of movement) as well as the supply-side (leisure facilities and closure of accommodation). According to FHRAI, "The Indian hotel industry's total revenue in FY 2019-2020 stood at Rs 182 million. As per our estimates, in FY2020-21, approximately 75% of the industry's revenues got wiped off. That is more than Rs 130 million revenue hit" (Business Standard, 2021). The Indian hospitality segment suffered a huge loss and is desperately looking forward to government support in terms of liquidity and policy support to survive and recover in 2021. As per the JLL survey, 60% of respondents believe that hotels will require one to two years to return to the levels of 2019. Out of the remaining 40%, half of the respondents posit that it will require more than 24 months, while the other half state it will require less than a year (JLL, 2020). Since hotels are such a key element of the hospitality sector, hotel owners think that most of the hotels in their portfolio will require working capital infusions to maintain or restart operations because reserves are nearly depleted (Tyagi, 2021). The government of India has announced a few schemes and developments to boost travel and tourism, such as the development of 17 iconic tourist sites, the Swadesh Darshan scheme, and marketing initiatives ('Incredible India!' and 'Atithi Devo Bhava'). Further, the Ministry of Tourism launched the National Integrated Database of Hospitality Industry (NIDHI) portal, Ministry of Road Transport and Highways launched 'All India Tourist Vehicles Authorisation and Permit Rules, 2021'. 100% Foreign Direct Investment (FDI) is permitted through the automatic method, and a five-year tax holiday is available for 2 up to 4-star hotels located near UNESCO World Heritage sites (IBEF, 2021).

The hospitality sector is vital to the economy. This sector should be guaranteed so that it recovers and thrives. The hospitality industry was the first to fall and last to rise. However, hospitality players are still confident of recovering the "lost enthusiasm in the second half of 2021" and are aiming at "revenge travel" once the health problem is under control. If this condition goes as planned, the industry will be able to recover. Key business cities and destinations in proximity to major cities with 5-6 hours of travel time will be the fast-recovering market as per 53% and 40% of the respondents, respectively, according to the JLL survey (JLL, 2020). This is also gaining momentum as we enter 2021, with vaccines building up confidence toward travel (Tyagi, 2021).

3. METHODS

This study performed analysis to both literature sources and real data from the real estate sector, which is considered the foundation for generalization of the current situation. However, considering the current scenario of COVID-19 where this study was conducted, data evaluation and collection wer primarily done through secondary sources, which included mainstream news and media, articles, reports, research papers, blogs of various companies such as Cushman and Wakefield, Knight Frank, CBRE, Oyo, etc.

Some of the keywords used to locate the literature sources during the research including the words of pandemics, COVID-19, real estate, residential sector, commercial sector, hospitality sector, and retail sector. Sources were selected and prioritized based on various criteria, such as the relevance of the topic in the Indian context, emerging trends, and variations in the data, recent surveys, and the current research. For research papers that were referred to, apart from the title and abstract, data collection and data analysis were considered to find H2 2007 to H1 2021. Sources were also shortlisted from the reference list of relevant articles, reports, and research papers. The collected data was further analyzed based on the thematic analysis using the NVivo software. Thematic analysis is a descriptive and explanatory method that uses

themes and patterns coming up repeatedly to analyze qualitative data. It helps organize and examine the data to obtain the results and draw conclusions (Guest et al., 2014).

The thematic analysis involved several steps, which cover:

1. Getting familiar with the data; The first step is to become acquainted with the data by reading it numerous times, which aids in structuring and identifying relevant information.
2. Grouping of data and searching for themes; This step includes categorizing the data into cohesive categories while simultaneously searching for distinct themes.
3. Interpretation and writing results; The data is turned into concrete sets of findings. In this step, the final analysis and conclusion for the topic are given.

NVivo is the software that organizes, stores, and analyzes data, which helps conduct a deeper qualitative data analysis and provides well-articulated and defensible conclusions. It is commonly applied in the thematic analysis through several processes, such as:

1. Importing; NVivo allows the data to be imported from various sources with different formats. This helped in centralizing the data on a single platform.
2. Organizing; The data is coded in different themes, which helps to identify the relevant data quickly.
3. Exploring; It also explores the coded data to visualize better using word frequency charts and word clouds. Hence, the data is better analyzed.
4. Connecting the dots; All these steps helped draw better conclusions.

4. DATA COLLECTION

4.1. Data on the Residential Sector

The residential sales in H1 2020 dropped to approximately 55,200 units from approximately 110,500 units in H1 2019. Further, the launch dropped around 42% in the same time frame (Knight Frank, 2020b). The unsold inventory was worth Rs. 3700000 million and stood at 455,351 units in Q2 2020, which was more than 442,228 units in Q1 2020 (Rao & Mamillapaui, 2020). The sales volume observed a 16% average quarterly growth in Q2 2020 than Q2 2019. However, a steep recovery of 54% was recorded in Q3 2020. Q4 2020 was even 5% higher than the average quarterly sales in Q4 2019. It has surpassed the pre-COVID level of residential demand. The launches volume experienced a similar growth during Q4 2020 compared with the average quarterly growth of 2019. Tier 1 cities grew 185% YoY in Q2 2021 and by 67% YoY in H1 2021 (Knight Frank, 2020c). Q1 2021 even witnessed the highest sales and launches as compared to the last few years, which stood at approximately 72,500 and 77,000 units, respectively. However, after the second wave, Q2 2021 saw a sequential drop of 62% and 43% in sales and launches. The value consisted of approximately 28,000 and 27,500 units, respectively. Vaccines sparked the market transaction in H2 2020, which carried this momentum to Q1 2021. Sales and volume in H1 2021 grew over 5% and 20%, respectively, as compared to H2 2020 (Knight Frank, 2020c).

Table 2: Quarterly sales and launches of 2020 (Knight Frank, 2020b)

	Q1 2020	**Q2 2020**	**Q3 2020**	**Q4 2020**
Sales (Housing units)	49,905	9,632	33,403	61,593
Sales as % of 2019 Quarterly average	81%	16%	54%	100%
Launches (Housing units)	54,905	5,584	31,106	55,033
Sales as % of 2019 Quarterly average	98%	10%	56%	99%

4.2. Commercial Sector

4.2.1. Office Segment

The year 2019 recorded the highest transaction of office spaces with a decade high of 27% and has exceeded 5.6 mn sq. ft. during the year. However, according to the Cushman and Wakefield report, the net leasing activity of office spaces has declined from 7 mn sq. ft. in Q1 2020, which was 30% higher than in 2019, to a 6-year low of 3.5 mn sq. ft. in Q1 2021 (Katsikakis et al., 2020)◘. In Q4 2020, this number increased to 9.9 mn sq. ft. with QoQ growth of 271% and has reached 115% of the pre-COVID level (Knight Frank, 2020b).

Table 3: Quarterly transactions and new completions of 2020 (Knight Frank, 2020b)

	Q1 2020	**Q2 2020**	**Q3 2020**	**Q4 2020**
Transactions mn sq. m. (mn sq. ft.)	1.4 (14.6)	0.2 (2.6)	0.4 (4.7)	1.6 (17.5)
Transactions as % of 2019 Quarterly average	96%	17%	31%	115%
New completions mn sq. m. (mn sq. ft.)	1.2 (13.2)	0.5 (5.2)	0.7 (7.1)	0.9 (10)
New completions as % of 2019 Quarterly average	86%	34%	47%	65%

In 2020, office completions dropped 42% YoY. Conversely, the new office supply in H1 2021 was 25.11 mn sq. ft. It increased 75% YoY across the major cities. The significant increase was especially caused by gradual unlocking and improved economic conditions so that various corporate occupiers were planning to renew their expansion projects with offices and business activities in the near future (Cushman & Wakefield, 2020).

As argued earlier, offices have shifted from traditional to hybrid mode. This shift has increased the demand for flexible office space in India. The value was 36 mn sq. ft. in 2020, and it is anticipated to expand by approximately 10-15 % by 2023, as per CBRE. The future of flexible office spaces includes 30%, while 60% is traditional occupancy, and 10% remains vacant. In the pre-COVID time, flexible office spaces were only 15%, while the other 80% was traditional occupancy. During that time, only 5% were vacant (World Economic Forum, 2021). Businesses also intend to access various work models to maintain flexibility at workstations and increase corporate profitability (CBRE, 2021).

4.2.2. Retail Segment

Malls have completely shut down during the lockdown. Mall leasing and new mall supply declined by almost 60%. In addition, the vacancy rate has also increased. Average rentals declined in the range of 5-6% across the tier 1 cities. The country, however, has shown signs of recovery in Q3 2020 with YoY growth of 1.6% (IBEF, 2021). Recoveries in terms of hypermarket, focusing on asset-light models, emerging e-tail, virtual change rooms and ease of technology, omnichannel strategy, contactless payments, flexible retail space models, and store size optimization were expected (Mohanty, 2020). Grade-A malls have shown higher growth rates than stable office asset molds. Mall density in India is lower but is likely to provide an immense scope of growth in the next few years, especially in tier 2 and tier 3 cities when the COVID has ended (Thomas, 2021). Online retail is forecasted to increase to US $84 by 2022 and US $200 by 2026 from US $73 in 2021 (IBEF, 2021).

4.3.3. Hospitality segment

India is a massive market for travel and tourism. It has been acknowledged as a renowned

tourism attraction for both local and foreign travelers. Unfortunately, India has witnessed a drop of over 25-30% in international visitors, as per the ministry of civil aviation, and a drop of over 30% in domestic travel. The decline of over 40% is seen in summer bookings to exotic places like Rajasthan and hills, with the highest impact on Leh, Guwahati, Coimbatore, and Amritsar. According to the WTTC's Economic Impact 2019 report, India's contribution increased by more than 4.9% in this sector, placing it third after China and the Philippines. Moreover, the number of jobs created during 2014-2019 also witnessed the strongest growth (IBEF, 2021). Since the pandemic broke out, jobs have become an issue as the situation has not improved till May 2020 (Praveenkumar, 2020). A shift in behavior after COVID would last for another 13 to 24 months, resulting in fewer hotel stays (Kakkar et al., 2020). Luxury hotel operators anticipated a delayed ramp-up by anticipating their portfolio to take more than two years to achieve 2019 overall performance. Travel will not return to pre-pandemic levels until 2023. Business travel is also predicted to shorten the post-pandemic period since companies would cut back on trip spending (Praveenkumar, 2020).

Up to FY 2019, Indian hotels have experienced a continuous growth momentum over the past few years. However, the hotel occupancy rate has fallen to 33.8% during FY 2021 and 65.4% during FY 2020 from 65.7% during FY 2019. To illustrate the havoc, the TATA group conglomerate's subsidiary, Indian Hotels Company Limited (IHCL), incurred a drop of 86% in its revenue from Rs 1,440 million in Q2 2020 to Rs 10,200 million in Q2 2019 due to COVID-19 (Kakkar et al., 2020).

Oyo, the unicorn of the Hotel industry in India, during FY19, booked total revenue of US $ 951 million. The value was 4.5 times higher than in 2018. The value was also marked by an increase in gross margin of 4.1% from 10.9% in FY18 to 14.7% in FY19 (Gupta, 2020). This number saw a downfall during the first wave, and close tracking was done for supply and demand equilibrium. In June and December 2020, Oyo reached 30% and 40% of pre-COVID levels, respectively (Moneycontrol, 2020). This was a small but significant green shot for Oyo hotels. “In India, if all goes well, in a couple of weeks, our numbers will be back to pre-wave two and then growing from there,” says OYO founder and CEO Ritesh Agrawal (BusinessLine, 2021).

5. RESULTS AND DISCUSSION

According to the literature and data, the residential segment has seen rapid growth despite the major obstructions. Government support and initiative, along with technology adaptation, have helped the segment recover and surpass the pre-COVID condition. People and organizations must be prepared for potential disruptions by breakthrough technology. In this context, intelligent buildings and systems that enable less contact in houses and buildings are likely to become increasingly widespread. People are renovating and upgrading their homes due to extended home-work choices and have increased the demand for larger units to accommodate a home office and digitally enabled homes.

Furthermore, commercial real estate is undergoing a structural shift as dramatic as it has seen in more than 200 years of history. The blend of a severe recession as well as a global outbreak has forced employees and businesses to reassess how frequently they will use their workplaces, how they will utilize the office differently in the future, and how much office space they will need.

“The impact of COVID-19 in the form of the shutdown of retail outlets and malls as also entertainment and fitness centers has put commercial real estate deals on a wait-and-watch mode,” says the national president of NAREDCO, founder and MD of Hiranandani Group, Niranjan Hiranandani (Mishra, 2021). The performance of shopping malls has declined, and

vacancy levels have risen, which creates funding challenges for mall developers. Major players in this segment, like DLF and Pheonix, are taking the lead in grade-A mall projects as they attract more crowds with premium brands and other facilities. Artificial Intelligence is augmented reality with more safety, to be an integral part of design post-COVID. Post-COVIDafter economic stabilization, this industry will make a strong comeback and deliver exceptional returns to investors (Thomas, 2021).

On the other hand, the hospitality segment still has a long way to go. As the hotel industry restarts operations, now are the time to adapt, revamp, and apply new methods and ideas to assist the sector in recovering faster and redefine hospitality for the future. Consumer behavior will be drastically altered in the post-COVID-19 world. The consumer would expect less in-person connection but the greatest hospitality and sanitary standards available. The sector should focus on increasing visitor and staff trust. To digitally interact and engage with guests, assessing them on different actions and guest care activities, as well as employee wellness programs, will assist develop the required assurance, as well as brand loyalty and value.

6. CONCLUSION

Real estate has certainly survived and eventually flourished as an asset class in the post-COVIDera, perhaps in a new form. There will certainly be major changes in the home, offices, and retail areas. The key themes of this change are decentralization, redistribution, and restructuring. The COVID-19 pandemic is eye-opening for everyone. Things can change quickly, and only those that innovate will be able to survive in such challenging times. Innovation and technology are critical to recovery, and those who refuse to adapt to changing circumstances will vanish.

The COVID-19 pandemic has significantly interrupted construction, made it impossible for many people to afford shelter, and has badly harmed the housing sector. Governments have responded by enacting a lot of policies to safeguard builders and lenders. The residential segment has proved its resilience, and with a few government initiatives and support, it has come back on track. The offices and retail segment in the commercial sector have geared up and almost reached their pre-COVID level. Innovations in both segments have accelerated growth and have given a newer perspective toward the future. Also, existing trends of hybrid working and online grocery services have accelerated due to the pandemic in the office and retail segments, respectively.

Hotels within the hospitality segment will need more attention to reach their pre-COVID level. This pandemic proved to be a turning point for the entire segment. Even when some re-openings take effect and vaccinations are distributed, “normal” everyday living remains a long way off for many. It must be seen which new methods of working and living customers grasp completely and which eventually become a memory of the outbreak.

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REVIEWING THE INDICATORS FOR ASSESSING CONSTRUCTION COMPANY AND PROJECT PERFORMANCE

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ABSTRACT

This paper is devoted to analyzing and systematizing indicators for assessing the performance of construction companies and projects. This topic is relevant because financial performance and other indicators of sustainable development are increasingly considered when determining the performance of construction companies. The systems of indicators developed by researchers for construction companies and projects are usually based on one of the three performance assessment models: the Balanced Scorecard Model (BSC), the European Foundation for Quality Management (EFQM), and the Key Performance Indicators (KPIs). In this study, we systematized the indicators presented in 18 papers on performance evaluation of construction companies and construction projects, published in 14 journals from 2014 to 2021. The analysis revealed that the top 13 performance factors mentioned in five papers included: safety and health, environment, cost, quality, profitability, time, client satisfaction, innovation, technology & learning, productivity, stakeholder satisfaction, people, business performance, and client & market focus. Thus, the analysis conducted of the scientific literature revealed that researchers' formation of performance indicators for construction organizations and projects emphasizes the satisfaction of all parties involved in a project's construction and operation processes. Furthermore, criteria related to safety, overall quality, cost, and environmental impact are found in 50% of the papers, signifying the high importance of these indicators. However, in three articles analyzed, 78% of all identified indicators were mentioned, indicating a lack of consensus within the scientific literature on specific metrics for assessing the performance of construction organizations and construction projects.

Keywords: Construction company performance; Effectiveness; Sustainable development; Key performance indicators; Balanced scorecard; European Foundation for Quality Management

1. INTRODUCTION

Management of companies is interested in developing models and systems of indicators that allow tracking efficiency and performance. Moreover, these indicators are related not only to the financial aspect of the companies' activities but also to other areas, namely social, environmental, innovation, etc. (Koroleva et al., 2020; Zeng et al., 2020). Sustainable infrastructure development increasingly becomes the subject of research (Abed & Yakhlef, 2020; Bellezoni et al., 2021; Raiden & King, 2021). Construction companies carry out direct work on the construction of infrastructure and its maintenance. Thus, when assessing the performance of construction companies, it is important to consider not only the financial indicators of their activities but also their contribution to the sustainable development of regions, imple-

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mentation of the strategic objectives of a company (Bhattacharya et al., 2021; Chen et al., 2020; Tereshko et al., 2021). Three basic models include the Balanced Scorecard Model (BSC), the European Foundation for Quality Management (EFQM), and the Key Performance Indicators (KPIs) are used to assess the performance of construction companies (Vukomanovic & Radujkovic, 2013). Oyewobi et al. (2017), Tripathi & Jha (2018), Soewin & Chinda (2022) have reviewed the literature on the performance indicators of construction organizations, and Mansour et al. (2020) on the performance indicators of construction projects. This study aims to identify total indicators for assessing construction company and project performance and includes more recent studies from 2014 to 2021. However, previous studies have proposed their parameters for evaluating the performance of construction organizations, using these models individually and in combination with one another. Therefore, it is advisable to conduct research to analyze the key performance indicators highlighted in the literature and their comparison. The purpose of this study is to determine the performance indicators of a construction company based on an analysis of scientific literature.

2. LITERATURE STUDY

Different models and key performance indicators can be used for a comprehensive assessment of the performance of a construction company. BSC, EFQM, and KPIs are the three main systems to assess a company's performance. The BSC model was developed by Kaplan & Norton (1992) that allows measuring and assessing the company's performance through an optimal set of indicators that reflect all aspects of the organization through four perspectives: finance; internal business processes; customers; innovation, training, and development. This model aligns the activities of all departments following a company's strategic objectives, monitors their achievement by managing deviations of the current values of indicators from the target ones, and adjusts business processes. However, the BSC model cannot be used for benchmarking a company against other companies in the market. For example, Luu et al. (2008) evaluated the performance of a construction company in Vietnam based on the integration of the BSC model and SWOT analysis. They then proposed eleven solutions to develop competitive advantages.

On the other hand, the EFQM model was put forward by the European Foundation for Quality Management in 1991. This model enables the comparison between a company and its competitors in the industry and identifies weaknesses and strengths to improve business processes. EFQM assesses a company's performance based on nine criteria, divided into two groups: opportunities and results. Opportunity criteria: leadership; people; policy and strategy; partnerships and resources; processes, products, and services. Results criteria: people development, benefits to customers, benefits to society, and key business results. Gasparik & Gasparikova (2014) identified the EFQM model as an effective tool for continuous quality improvement and customer satisfaction, success in local and global markets, and enhancing the culture of an entire organization. As part of their research, these authors created electronic guidelines for implementing and assessing the criteria and sub-criteria of the EFQM model in a construction company and developed the software.

Meanwhile, the KPIs model is a simple tool for measuring performance in a company; it allows for assessing the achievement of set financial and operational goals. KPIs can be divided into two types of factors: (1) lagging: reflecting the performance at the end of the period; and (2) leading: allowing predicting what will happen in the future, thereby managing the situation within the reporting period, to make adjustments. The study by Radujković et al. (2010) identified low awareness of KPIs models among construction companies in South-East Europe. Based on a literature review, interviews, and surveys with company representatives, it identified 37 KPIs to

assess the performance of construction companies and then provided recommendations for their implementation in practice.

In addition, hybrid systems for assessing the performance of construction companies, integrating several models, have also been developed. For example, Oyewobi et al. (2015) proposed a model incorporating the BSC model with the Business Excellence Model (BEM) to assess the performance of construction organizations. On the other hand, Vukomanovic et al. (2014; 2013) also proposed models integrating the EFQM and BSC models for benchmarking, identifying best practices, aligning strategy with the competitive environment, and selecting key performance indicators aligned with strategy. Combining these models enable organizations to achieve excellent results while having a sustainable competitive advantage and the ability to adapt their approach to a changing environment based on regular performance monitoring.

3. METHODS

In this study, the indicators of performance or productivity of a construction company are determined based on a qualitative method by conducting a bibliographic review in three stages. In the first stage, Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement was utilized to select papers in which the performance of construction companies and construction projects is assessed.

Peer-reviewed journals indexed in Web of Science (WoS) and Scopus were analyzed. These two databases were considered for data collection owing to their wide utilization. For example, research by Lima et al. (2021) used WoS data for conducting a systematic literature review dedicated to sustainability in the construction industry. Audy by Tay et al. (2017) also used WoS and ScienceDirect to review 3D printing trends in the building and construction industry. The keywords and titles used in the search from 2014 to 2021 include “construction” and “key performance indicators”. The search resulted in 490 records. However, after several refinements in the search, 18 articles were selected to be analyzed using the PRISMA approach (see Figure 1).

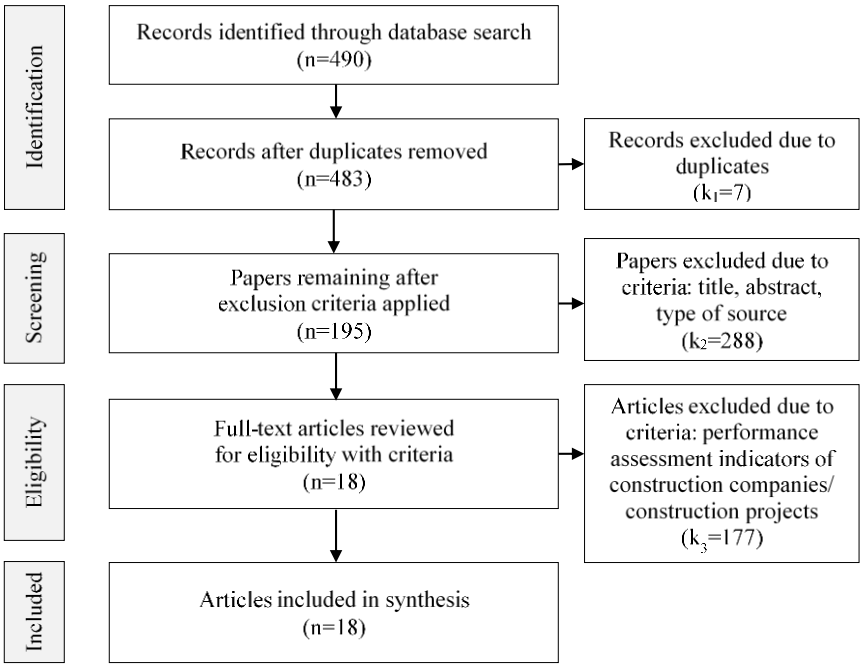

Figure 1 Prisma Flow Diagram

In the second stage, the papers for the performance factors presented were analyzed to develop a list of indicators for each paper. A table was created based on the list of indicators, demonstrating which factors are mentioned in each paper. At the intersection of the line with the factor and the column with the author number, when this factor is present in the paper, a 1 is put; or if this factor was not identified, it is left an empty field. Lastly, the frequency for each factor is calculated, and their rating is compiled in the third stage.

4. RESULTS AND DISCUSSION

In the first stage of the study, 18 journals were selected, including research on the construction industry. Consequently, 18 papers on performance assessment of construction companies and construction projects published in 14 international journals from 2014 to 2021 were selected. Table 1 provides information on the journal titles and the distribution of papers. The greatest number of relevant studies is in the International Journal of Construction Management, followed by the Journal of Construction Engineering and Management.

Table 1 Distribution of papers by journal

Journal Name	WoS Indexed	Journal Citation Indicator (JCI) 2020	Scopus Indexed	SCImago Journal Rank (SJR) 2020	No. of Papers
International Journal of Construction Management	✓	1.310	✓	0.505	4
Journal of Construction Engineering and Management	✓	3.951	✓	0.967	2
Journal of Facilities Management	✓	0.480	✓	0.461	1
Journal of Civil Engineering and Management	✓	0.770	✓	0.529	1
Construction Innovation	✓	0.530	✓	0.455	1
Journal of Management in Engineering	✓	1.270	✓	1.646	1
Engineering, Construction and Architectural Management	✓	0.740	✓	0.585	1
Journal of Computing in Civil Engineering	✓	1.050	✓	0.936	1
Journal of Engineering, Design and Technology	✓	0.470	✓	0.260	1
International Journal of Construction Management	✓	1.310	✓	0.505	1
Journal of Financial Management of Property and Construction	✓	0.530	✓	0.297	1
International Journal of Managing Projects in Business	✓	0.590	✓	0.739	1
Built Environment Project and Asset Management	✓	0.400	✓	0.335	1
KSCE Journal of Civil Engineering	✓	0.530	✓	0.503	1

The distribution of studies by year is shown in Table 2, where the largest number of selected papers were published in 2020, with six papers, followed by 2017 with four papers. Furthermore, the titles of the papers and their authors are presented in chronological order in Table 3. Moreover, to identify the papers at the next stage, each was assigned a number in the first column corresponding to a sequential number.

Table 2 Distribution of the number of papers by year

Year	No. of Papers
2014	1
2015	1
2016	2
2017	4
2018	2
2019	1
2020	6
2021	1

Table 3 The articles analyzed in this study

No.	Authors	Title of the Article	No. of Citations in Google Scholar by November 2021
1	Hanna et al. (2014)	Mathematical formulation of the project quarterback rating: new framework to assess construction project performance	20
2	Oyewobi et al. (2015)	Measuring strategic performance in construction companies: a proposed integrated model	37
3	Ofori-Kuragu et al. (2016)	Performance measurement tools for Ghanaian contractors	11
4	Hu et al. (2016)	Developing a program organization performance index for delivering construction megaprojects in China: Fuzzy synthetic evaluation analysis	68
5	Elwakil (2017)	Integrating analytical hierarchy process and regression for assessing construction organizations' performance	16
6	Işik & Aladağ (2017)	A fuzzy AHP model to assess sustainable performance of the construction industry from urban regeneration perspective	31
7	Jonsson & Rudberg (2017)	KPIs for measuring performance of production systems for residential building	25
8	Oyewobi et al. (2017)	Determinants of construction organizational performance	11
9	Wu et al. (2018)	DEA-based performance evaluation system for construction enterprises based on BIM technology	6
10	Tripathi & Jha (2018)	An empirical study on performance measurement factors for construction organizations	42
11	Mellado et al. (2020)	Synthesizing performance in the construction industry: An analysis of performance indicators to promote project improvement	14

No.	Authors	Title of the Article	No. of Citations in Google Scholar by November 2021
12	Khanzadi et al. (2020)	BIM applications toward key performance indicators of construction projects in Iran	32
13	Mansour et al. (2020)	Development of an impact-on-performance index (IPI) for construction projects in Malaysia: a Delphi study	3
14	Soewin & Chinda (2020)	Development of a construction performance index in the construction industry: system dynamics modelling approach	7
15	Tuffaha et al. (2020)	A framework for the performance assessment of construction contractors in Saudi Arabia	0
16	Ingle et al. (2021)	Identifying the performance areas affecting the project performance for Indian construction projects	4
17	Budayan et al.(2020)	Identification and prioritization of stage-level KPIs for BOT projects–evidence from Turkey	6
18	He et al. (2021)	Developing a List of Key Performance Indicators for Benchmarking the Success of Construction Megaprojects	10

The second stage resulted in the formation of Table 4, reflecting the information about the identified performance indicators for each study. In general, the authors identify from 4 to 20 factors that characterize the performance of a construction company and its projects.

Table 4 Indicators of performance by paper

Indicators	Paper Number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Time			✓	✓					✓		✓		✓	✓	✓			
Cost			✓	✓			✓		✓		✓		✓	✓	✓	✓		
Quality			✓	✓			✓			✓	✓		✓	✓	✓	✓		
Productivity			✓								✓		✓		✓	✓		
Environment				✓	✓	✓				✓	✓		✓	✓	✓	✓		✓
Client satisfaction		✓	✓								✓		✓	✓	✓			
Profitability	✓	✓				✓				✓	✓				✓	✓		
People		✓	✓					✓			✓				✓			
Safety and Health			✓	✓		✓				✓	✓	✓	✓	✓	✓	✓		✓
Business performance		✓	✓		✓	✓									✓			
Construction speed	✓															✓		
Rework	✓																	
Innovation, technology & learning					✓	✓		✓			✓			✓			✓	
Communication	✓												✓			✓		
Customer satisfaction									✓				✓	✓	✓			
Employee satisfaction					✓	✓							✓	✓				
Stakeholder satisfaction						✓				✓			✓	✓		✓		
Financial performance						✓								✓				
Owner satisfaction														✓				✓
Government'ssatisfaction														✓				✓
Delivery speed and dependability	✓						✓									✓		

Indicators	Paper Number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Volume and mix flexibility							✓											
Relations (Return business, claims, feedback)	✓				✓				✓							✓		
Corporate image promotion/brand									✓									✓
Material & resources management		✓				✓			✓									
Investment decision-making analysis									✓									
Contract information management									✓									
Asset management					✓					✓								
Predictability of time and cost										✓		✓			✓			
Low staff turnover										✓								
Social responsibility		✓				✓												
Client & Market focus		✓			✓	✓		✓										✓
Leadership		✓																
Information management		✓																
Suppliers & Partnership Performance		✓				✓											✓	
Strategy & Planning		✓			✓													
Business result		✓																
Market share								✓										✓
Meeting regulations or specifications															✓			
Enhancing people's national pride and confidence						✓												✓
Delivering socioeconomic benefits to the community						✓												✓
Clash Detection												✓						
Site Layout Planning												✓						
Project management												✓						
Integration of Subcontractor and Supplier Data												✓						
Prefabrication												✓						
Construction Monitoring												✓						
Total quality management					✓												✓	
Organizational structure (management style)								✓										
Number of full-time employees					✓													
Product maintenance					✓													
Research and development					✓													
Long-term contribution of the project to the company/industry						✓												
IT use in construction					✓	✓												
Public satisfaction						✓												
CO2 emission from the building						✓												
Waste management						✓												

Indicators	Paper Number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sustainable design						✓												
Comprehensiveness of project technical feasibility																	✓	
detailed tendering procedure																	✓	
Knowledge					✓												✓	
Facility management																	✓	
Hand-back management																	✓	
Intensity	✓							✓										
Schedule growth	✓																	
Construction unit cost	✓																	
RFI Processing Time	✓																	
Resubmittals	✓																	
Total changes	✓																	
Change Order Processing time	✓																	
Percent plan complete trend	✓																	
Munificence								✓										
Decision-making style								✓										
Cost leadership strategy								✓										

In the third stage, the frequency of performance indicators in the studied papers was calculated based on their ranking (Table 5). Therefore, the top 13 performance factors comprise of safety and health, environment, cost, quality, profitability, time, client satisfaction, innovation, technology & learning, productivity, stakeholder satisfaction, people, business performance, and client & market focus. Thus, the analysis of scientific literature revealed that researchers, when forming performance indicators of construction organizations and projects, emphasize the satisfaction of all parties involved in constructing and using an object. Also, criteria related to safety, overall quality, cost, and environmental impact are found in 50% of the papers, indicating the high importance of these indicators. At that, 58 indicators out of 74, 78% of all identified indicators were mentioned in three fewerless analyzed papers.

Table 5 Ranking of the identified factors and the frequency of their mention

Rank	Factor	Score	Rank	Factor	Score
1	Safety and Health	11	37-74	Contract information management	1
2	Environment	10	37-74	Low staff turnover	1
3-4	Cost	9	37-74	Leadership	1
3-4	Quality	9	37-74	Information management	1
5-6	Profitability	7	37-74	Business result	1
5-6	Time	7	37-74	Human resources management	1
7-8	Client satisfaction	6	37-74	Human resources development	1
7-8	Innovation, technology & learning	6	37-74	Sales growth	1
9-13	Productivity	5	37-74	Quality cost	1
9-13	Stakeholder satisfaction	5	37-74	Meeting regulations or specifications	1
9-13	People	5	37-74	Clash Detection	1
9-13	Business performance	5	37-74	Site Layout Planning	1
9-13	Client & Market focus	5	37-74	Project management	1

Rank	Factor	Score	Rank	Factor	Score
14-16	Customer satisfaction	4	37-74	Integration of Subcontractor and Supplier Data	1
14-16	Employee satisfaction	4	37-74	Prefabrication	1
14-16	Relations (Return business, claims, feedback)	4	37-74	Construction Monitoring	1
17-21	Communication	3	37-74	Organizational structure (management style)	1
17-21	Delivery speed and dependability	3	37-74	Number of full-time employees	1
17-21	Material & resources management	3	37-74	Product maintenance	1
17-21	Predictability of time and cost	3	37-74	Research and development	1
17-21	Suppliers & Partnership Performance	3	37-74	Long-term contribution of the project to the company/industry	1
22-36	Owner satisfaction	2	37-74	Public satisfaction	1
22-36	GGovernment'ssatisfaction	2	37-74	CO2 emission from the building	1
22-36	Strategy & Planning	2	37-74	Waste management	1
22-36	Market share	2	37-74	Sustainable design	1
22-36	Construction speed	2	37-74	Comprehensiveness of project technical feasibility	1
22-36	Financial performance	2	37-74	detailed tendering procedure	1
22-36	Corporate image promotion/brand	2	37-74	Facility management	1
22-36	Asset management	2	37-74	Hand-back management	1
22-36	Social responsibility	2	37-74	Schedule growth	1
22-36	Enhancing people's national pride and confidence	2	37-74	Construction unit cost	1
22-36	Delivering socioeconomic benefits to the community	2	37-74	RFI Processing Time	1
22-36	Total quality management	2	37-74	Resubmittals	1
22-36	IT use in construction	2	37-74	Total changes	1
22-36	Knowledge	2	37-74	Change Order Processing time	1
22-36	Intensity	2	37-74	Percent plan complete trend	1
37-74	Rework	1	37-74	Munificence	1
37-74	Volume and mix flexibility	1	37-74	Decision-making style	1
37-74	Investment decision-making analysis	1	37-74	Cost leadership strategy	1

Articles written by Hu et al. (2016), Mellado et al. (2019), Mansour et al. (2020), Soewin & Chinda (2020), Tuffaha et al. (2020), and Ingle et al. (2020) are the only papers marked the value of four important factors for a construction company and project performance, which include safety and health, environment, cost quality. Therefore, there is no consensus in the scientific literature on determining the indicators that could be used to assess the performance of construction companies and projects. It can be explained by the fact that most indicators highlighted by scientists when developing performance assessment models are unique and have not been fully verified or accepted by the community at the idea level.

On the other hand, Hanna et al. (2014), Khanzadi et al. (2020), Oyewobi et al. (2017), and Budayan et al. (2020) identified several indicators, more than 40% of which are not repeated in any other article. It might be due to the different methods used to evaluate the indicators, the specifics of projects, and the overall construction market in different countries. Also, many indicators and parameters are difficult to measure, for example, knowledge or decision-making style.

5. CONCLUSION

The study analyzed 18 papers published from 2014 to 2021 discussing the performance assessment of construction companies and construction projects. Performance indicators for each study were identified, where the authors generally suggested undertaking an assessment using 5-20 factors. The results of this study show the ranking of the 13 most common indicators include safety and health, environment, cost, quality, profitability, time, client satisfaction, innovation, technology & learning, productivity, stakeholder satisfaction, people, business performance, client & market focus.

It should be noted that the studies under consideration often identify general performance indicators that can be used not only to assess the activities of construction companies and projects but also for companies in other industries. However, if a company wants to improve its efficiency, it is necessary to consider more industry-specific performance indicators which further influence the general performance indicators. Thus, the development of specific indicators for assessing the performance of construction organizations can be regarded as areas for further research. These indicators can be developed through the analysis of activities of individual departments, company business processes, and project implementation stages.

Future research directions include developing an integrated performance system, which will contain indicators approved by practitioners. Evaluation by specialists from construction companies will allow the distribution of the weights between factors and assess their significance. As a result, we will be able to determine the significance of the performance indicators depending on the country, industry, and company development level.

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EVALUATING THE IMPLEMENTATION OF SOLAR HOME SYSTEMS (SHS) IN SUMBA – EAST INDONESIA

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ABSTRACT

The lowest electrification rate in Indonesia is in East Nusa Tenggara (NTT) province, leading to a high poverty rate and low education level. At the same time, NTT has higher solar irradiance than the Indonesian average, which can be used for electrification. In 2019-2021, seventeen (17) Solar Home Systems (SHS) were installed in churches with no electricity grid connection to address these challenges. These systems serve church community activities as well as learning centers for students. The first system design was improved and adopted in 2020 and 2021 to meet users' needs better. However, the COVID-19 pandemic made it difficult to visit and monitor the first installations for around two years. Therefore, the attempt to evaluate the SHS project remains a challenge. In March 2022, surveys were conducted in this study to assess the SHS' installation quality, the electrification situation, and how to improve existing and future SHS' installations. The results show that the electrification ratio was increasing fast, and SHS has a positive economic impact compared to diesel generators. Furthermore, to improve its usability and decrease its failure, active service is key to increasing working SHS and improving its usage.

Keywords: Electrification; Off-grid; Renewable Energy; Solar Home Systems (SHS); Sumba

1. INTRODUCTION

Sumba is one of the islands in the East Nusa Tenggara o(NTT) province of Indonesia. It has an area of about 11,000 square meters. Sumba's neighboring islands are Sumbawa to the northwest, Flores to the northeast, Timor to the east, and Australia to the south and southeast. The Sumba Strait is located on the island's north, while the Savu Sea lies to the east and the Indian Ocean to the south and west. According to the Central Bureau of Statistics (BPS) of East Nusa Tenggara (2021a), Sumba's population was estimated to be 788,189 in 2021.

The year in Sumba is divided into rainy and dry seasons, where the dry season is longer than the rainy season. The rainy season usually happens from December to April, and the remaining eight months are dry. The rainfall in Sumba ranges from 0 mm to 294 mm (BPS East Nusa Tenggara, 2021b). The highest number of rainy days is less than 25 days, while the national average number of rainy days is 226. The temperature range is about 15-36 degrees Celsius. Moreover, according to the Global Solar Atlas map, Sumba has huge potential for daily global horizontal solar irradiation of 4.8-6.0 kWh/m2, above Indonesia's average.

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However, the electrification ratio of NTT Province in the last five years is the lowest among others in Indonesia. The electrification ratio is the ratio of the number of electrified household customers from PT PLN as the state electricity company and non-PLN electricity to the total number of households. Figure 1 shows the electrification ratio of East Nusa Tenggara compared to the national average (Ministry of Energy and Mineral Resource, 2018, 2019, 2020, 2022).

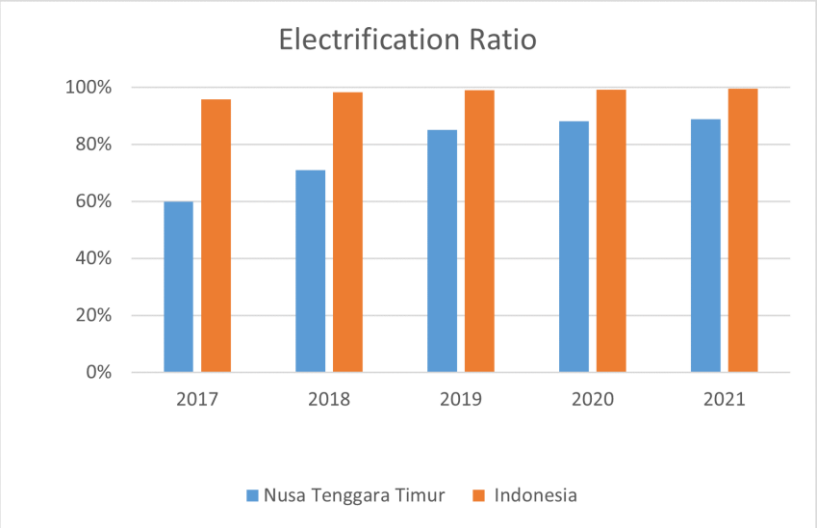

Figure 1. The electrification ratio of NTT compared to Indonesia

Sumba Timur has the highest number of poor people, 3.5 times higher than the national percentage. The percentage of poor people in Sumba is shown in Figure 2.

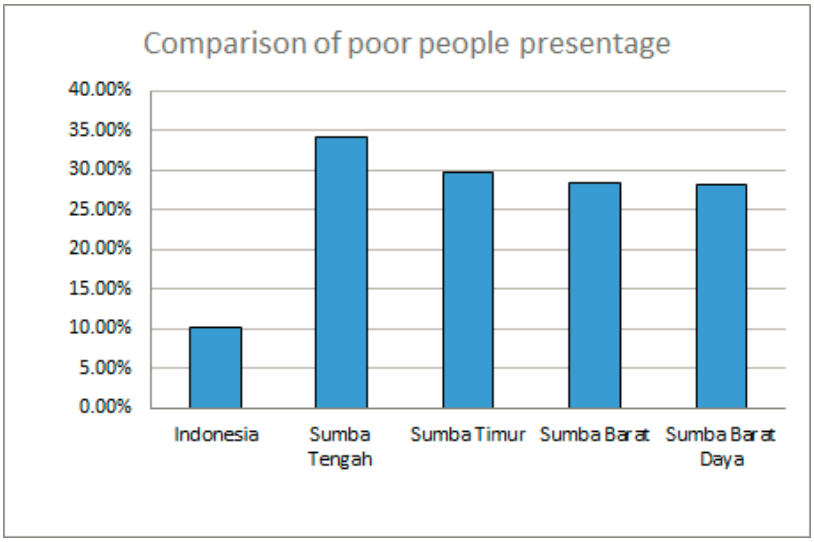

Figure 2. Percentage of poor people in Sumba compared to Indonesia

According to Indonesia's poverty data for the year 2021 from BPS Indonesia (2021), the percentage of poor people aged 15 years and older who completed their senior high school and higher education in NTT was 10 % lower than the national average. Figure 3 shows the percentage of poor people aged 15 years and older by provinces and senior high school education and higher education completed.

Energy is important in raising education levels that may lead to improved economic growth, allowing individuals to overcome poverty (Karekezi et al., 2012; Sule et al., 2022). The indirect benefit of utilizing solar home systems may lead to a better life and health quality, prolonged work duration, the creation of new businesses and new jobs, and adding at least two productive activities for people (GOGLA, 2018).

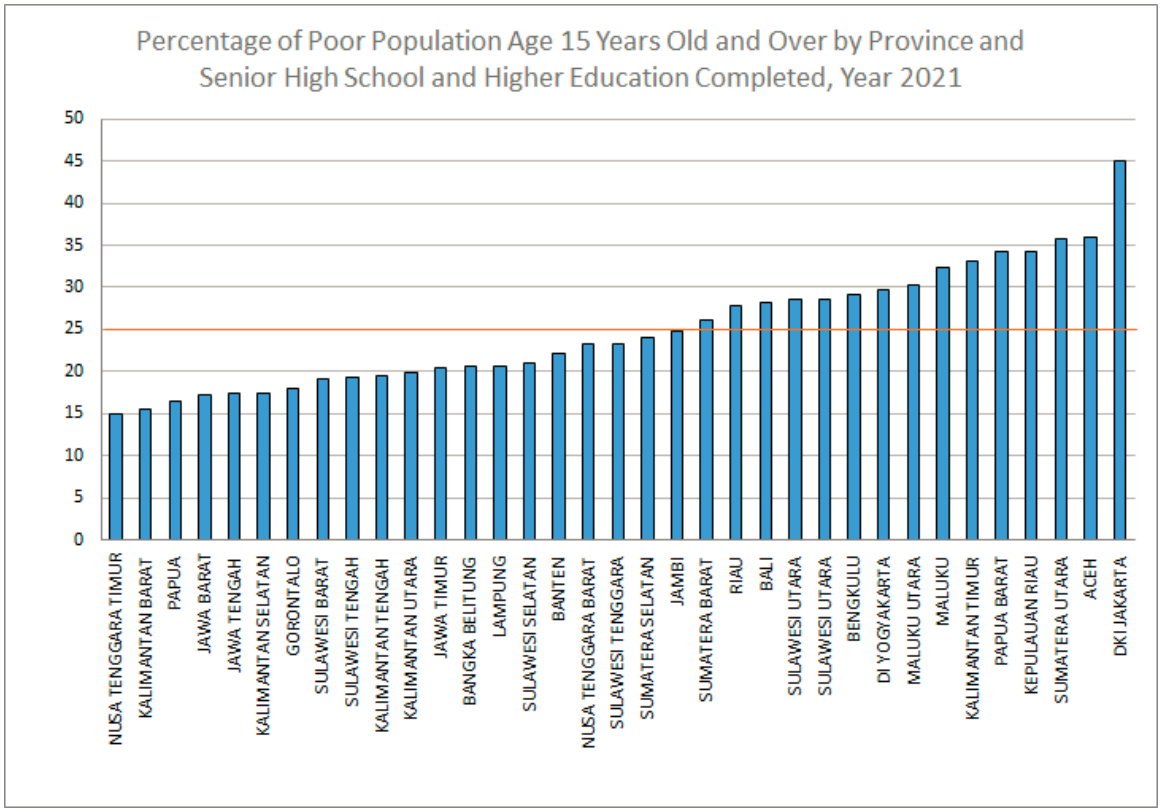

Figure 3. Percentage of poor people aged 15 years old and older by province and senior high school and higher education completed in 2021

The high solar irradiation levels make solar energy the most promising energy source that can be developed in Sumba to strengthen renewable energy sources (Budi et al., 2020). Depending on the village size and density, off-grid central solar systems or smaller capacities of individual Solar Home Systems (SHS) can supply energy. However, existing SHS installations face malfunction problems within a short period due to the lack of after-sales and maintenance services.

Some studies and surveys were conducted to understand the situation and the needs of the people before SHS installation (Apple et al., 2010; Lam et al., 2012). It was found that some remote villages in Sumba and Timor did not have electricity access. Even though some people already have small SHS for lighting; however, they must go to a nearby electrified village for phone charging at a rate of IDR 2,000 – 5,000 (EUR 0.12 – 0.30) per phone charge.

Meanwhile, people without electricity or SHS in their houses use kerosene lamps as lighting at night in a limited source. Therefore, children rarely learn in the evening. This lack of lighting also impacts security, for example, cases of theft of livestock, damage to agricultural land, and the destruction of public facilities. Furthermore, using kerosene lamps also has negative health impacts due to the high concentration of particulate matter (PM) 2.5 emissions.

Therefore, seventeen (17) SHS were installed at the churches in Sumba and Timor to provide electricity, starting from 2019 to 2021. Before the installation, SHS components and system simulations were conducted to meet the church's electricity needs. The churches were chosen since they were the central meeting points for the public. Monitoring and evaluation were held towards the installed SHS by visiting 9 (nine) churches in March 2022. Some system malfunctions were also analyzed and fixed to ensure system sustainability. Moreover, questionnaires were developed to evaluate the SHS installation, usage, and outcome. During the church's visitation, constructive dialogues were conducted with the user to understand project implementation better.

2. METHODS

2.1. Project Situation

The center for renewable energy development of Universitas Kristen Immanuel (UKRIM) installed SHS focused on Sumba's five churches not connected to the electricity grid in 2019. The churches usually rent generator sets (genset) for evening church activities, with total costs oat IDR 200.000 (€12) for one evening event. For economic reasons, annual evening events are often limited to only a few occasions, less than five per year.

After the installation in 2019, more churches asked for SHS to improve their situation. Until January 2022, 14 (fourteen) SHS were installed in Sumba and 3 (three) other systems in Timor. The location of SHS installed in Sumba in 2019-2020 can be seen in Figure 4, where blue spots are where the SHS were installed in 2019, green spots were installed in 2020, and red spots were installed in 2021.

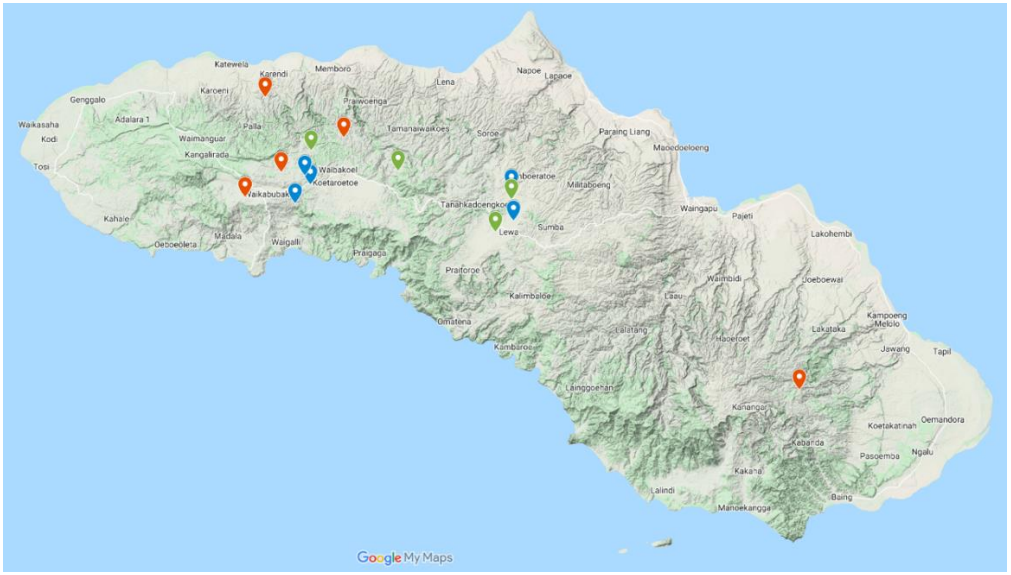

Figure 4. Location of SHS installations

2.2. The Objective of the SHS Installation in Churches

The projects were financially supported by the donor who wanted to help with the electricity situation at the churches. Churches are often used as gathering centers for people in NTT; therefore, more people can access the electricity for weekly worship and phone charging, while students living nearby can use it for studying at night. Moreover, churches are considered

trusted institutions to use the system responsibly. The objective of the SHS installation was to provide reliable electricity for churches in remote areas. The church community can gather for evening events like Christmas service, but the light can also be used for other activities.

2.2. The Benefits of the SHS Installations

Our goal is to bring lighting to churches where there is no access to electricity and especially to people who live around churches. The installed SHS brings several benefits to the users. With adequate lighting, the church can organize evening activities, such as evening worship, holding community meetings, and making crafts, further strengthening the community, and increasing income. Learning centers can be arranged, and students can learn together and improve their educational level using the light. The security situation can be increased by using lights during the night. To charge their phones, people do not have to go to another electrified village but charge it (with permission from the church management) at the church. Internet connection has become more important, especially since digitalization increased during the covid19 pandemic. Compared to gensets, a solar home system is more economical. If the solar home system is used only twice a week, the return on investment is less than one year compared to fuel costs to run a genset. Moreover, the SHS does not produce noise or CO_2 emissions.

2.4. SHS Components

2.4.1. The SHS's main components

The SHS's main components consist of photovoltaic (PV) modules, a battery, and a solar charge controller. PV modules absorb and convert solar radiation as an energy source into electrical energy. A PV module is a connected assembly of several similar solar cells. The electricity generated from a PV module depends on the amount of radiation falling on the surface of the module, meaning that the orientation of the module, weather, and cleanliness must be considered (Quaschning, 2016).

The PV module size was calculated during the Internal Workshop at UKRIM in 2021), using the equations below:

$$PSH\ (h) = \frac{GHI\ (kWh/m^2/}{1000\ (W)} \quad (1)$$

$$Capacity\ needed\ (W) = \frac{Total\ daily\ consumption\ (}{PSH\ (h)} \quad (2)$$

Where Peak Sun Hour (PSH) is the equivalent area of total energy captured throughout the day, while Global Horizontal Irradiation (GHI) in Waikabubak, West Sumba, is 5.3 kWh/m²/day (Global Solar Atlas, 2022).

The battery is the next main SHS component. Since the PV modules produce electricity only during sun hours, the battery plays an important role in the energy system. Batteries are required for the storage of excess energy production from PV modules. The type of battery used is different from vehicle batteries. The battery used in the SHS installation in Sumba is a deep-cycle battery. This battery is a type of battery that is designed to produce stable energy (electric current) for a long period. The battery must be placed in a closed location with good air circulation (Quaschning, 2016).

The battery size was calculated as follows:

$$Energy\ requirement\ (Wh) = Total\ daily\ consumption\ (Wh) \times self\ sufficiency\ days\ (day) \times charge\ loss \quad (3)$$

$$Battery\ capacity\ (Ah) = \frac{Energy\ requirement\ (Wh)}{System\ voltage\ (V)} \quad (4)$$

The solar charge controller, or charge controller, is a voltage and current regulator to keep the battery from overcharging. This SHS main component regulates the voltage and current from the PV module to the battery. This appliance should be in a place that is safe from water and has easy access to fuses and electrical terminals (Fuentes et al., 2018; Mazibane et al., 2019).

2.4.1. The SHS's additional components

Some additional components in SHS include switch boxes, cables, and fuses. The switch box was used for connecting electronic equipment placed in several positions (e.g., main room lights, porch lights, small room lights) to the on/off switch of the lamps and other appliances. The switch box was designed and built by UKRIM students to help users save their electricity consumption. Although it is made with a waterproof box, the switch box should be placed indoors and kept away from water and insects to avoid connection failure.

Furthermore, cables must be properly labeled, color-coded, well-insulated, and adequately attached to the components to ensure a good installation. Selecting the correct cable size will reduce energy losses in system operation (Fuentes et al., 2018). In addition, fuses are important for overcurrent protection. The right fuse selection will secure the PV system and the connected electronic equipment. It can be placed between the PV module with the solar charge controller, between the solar charge controller and the battery, and between the Solar charge controller and the switch box (Mazibane et al., 2019). The circuit diagram of the installed SHS can be seen in Figure 5.

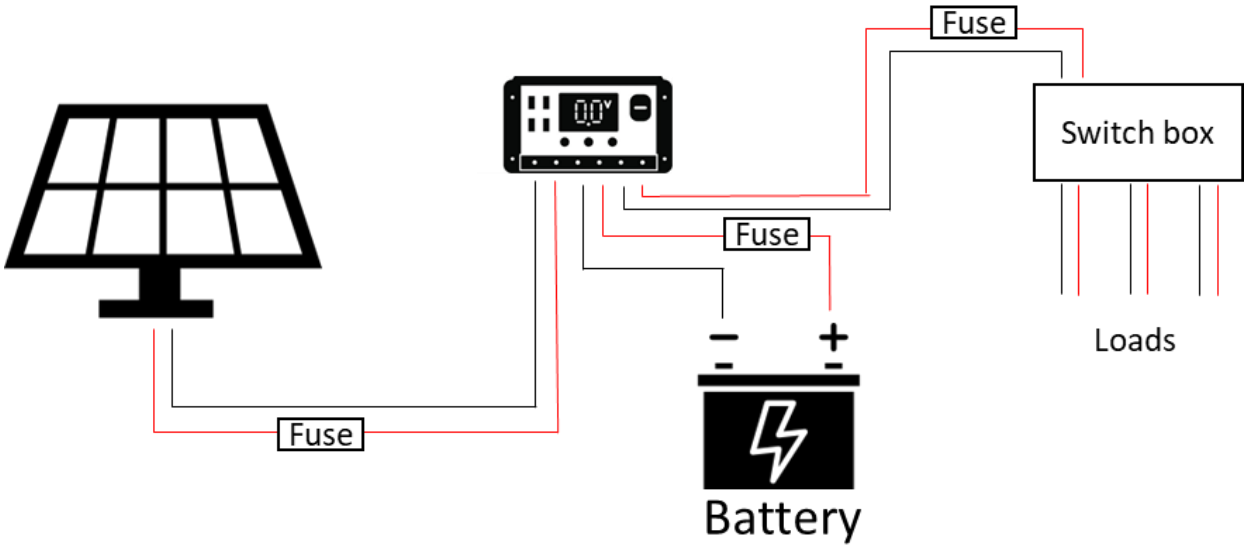

Figure 5. Diagram of SHS components

2.5. SHS Development

During the four years of this project, several improvements to several components were made, as can be seen in Table 1. During the 2019 project, the researchers got to know the situation better and improved the installations to meet the needs better. In 2020, it was discovered that some churches used loudspeakers by connecting the wires directly to the battery. For the safety and durability of the SHS and the appliances, the switch box was upgraded by adding 12 volts DC output plug that can be used for the loudspeaker system and other 12V devices. Since 2021, Solar Charge Controllers (SCS) has been used with a display showing the voltage and four-bar battery status so that users can manage energy consumption accordingly to the battery status. The SCS also has two integrated USB plugs; hence, the switch box design could be simplified. The size of the solar modules increased from 100Wp to 120 Wp for faster battery charging during the rainy season, and the battery capacity decreased from 100Ah to 80 Ah, as discussed in the subsection below.

Table 1. Description of Components of solar home system

Components	**2019**	**2020**	**2021**	**2022**
PV modules	Capacity: 100 Wp Series: Polycrystalline silicon / SW100P	Capacity: 100 Wp Series: Polycrystalline silicon / SW100P	Capacity: 120 Wp Series: Monocrystalline silicon	Capacity: 120 Wp Series: Monocrystalline silicon
Battery	Capacity: 100 Ah Series: LPC Series – Deep Cycle	Capacity: 100 Ah Series: LPC Series – Deep Cycle	Capacity: 80 Ah Series: SEG12-80/ gel series battery	Capacity: 80 Ah Series: JP80-12 G/ VRLA gel battery
Solar Charge Controller	Capacity: 12/24VDC, 10 A Series: PWM, LS2024R	Capacity: 12/24VDC, 10 A Series: PWM, LS2024R	Capacity: 12/24VDC, 20 A Series: PWM, VS2024AU with 2 USB plugs	Capacity: 12/24VDC, 20 A Series: PWM, VS2024AU with 2 USB plugs
Switch box	Three switches and one USB port	Three switches and one USB port	Three switches	Three switches
Survey	Without questionnaire	Paper-based questionnaire	Paper-based questionnaire	Online questionnaire and local assistants
Output	Five bulbs in total One USB port	Five bulbs in total One USB port One 12VDC port	Five bulbs in total Two USB ports One 12VDC port	Five bulbs in total Two USB ports One 12VDC port
Systems installed	Five systems	Four systems	Five systems + three systems at Soe	Five systems were installed in June 2022

2.6. Simulation Results

2.6.1. The SHS in 2019-2020

A simulation was run using the Photovoltaic Geographical Information System, accessed on the website https://re.jrc.ec.europa.eu/. In 2019, the system used a 100 Wp panel capacity and a 100 Ah battery. Table 2 and Figure 5 show the simulation results for systems with the above capacities.

Table 2. The simulation results for SHS in 2019-2020

Provided Inputs		Simulation Outputs	
PV installed [Wp]:	100	Percentage days with full battery [%]:	83.03
Battery capacity [Wh]:	1200	Percentage days with empty battery [%]:	1.44
Discharge cutoff limit [%]:	50	Average energy not captured [Wh]:	110.2
Consumption per day [Wh]:	300	Average energy missing [Wh]:	92.25
Slope angle [°]:	10		
Azimuth angle [°]:	180		

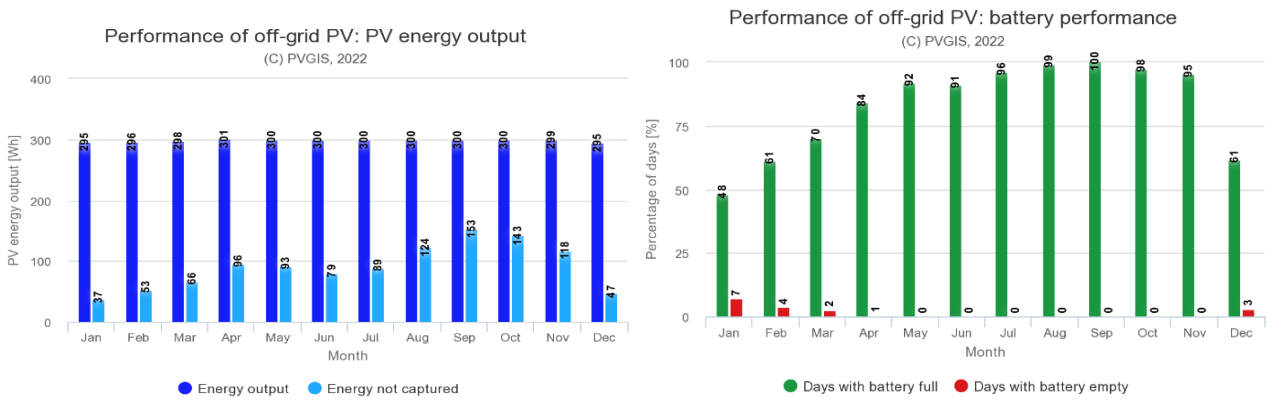

Figure 6. Simulation result of PV energy output and battery performance of SHS in 2019-2020

2.6.2. The SHS in 2021-2022

Based on reports from several users in 2019-2020, the solar charge controller often showed a red light indicating the battery was almost empty, even on sunny days. The report was finally evaluated and concluded to increase the capacity of the PV module to 120 Wp and reduce the battery capacity to 80 Ah. The lower battery capacity helps recharge it faster. Table 3 and Figure 7 show the simulation results for systems with the capacities. As a result, the days without batteries could be decreased by 50% from 16 to 8 days. Feedback from users confirmed that their systems no longer show a red light. The system costs did not change significantly as the smaller battery was cheaper, and the solar module prices decreased over the years.

Table 3. The simulation results for SHS in 2021-2022

Provided Inputs		Simulation Outputs	
PV installed [Wp]:	120	Percentage days with full battery [%]:	93.02
Battery capacity [Wh]:	960	Percentage days with empty battery [%]:	0.75
Provided inputs:		Simulation outputs:	
Discharge cutoff limit [%]:	50	Average energy not captured [Wh]:	181.47
Consumption per day [Wh]:	300	Average energy missing [Wh]:	81.86
Slope angle [Â°]:	10		
Azimuth angle [Â°]:	180		

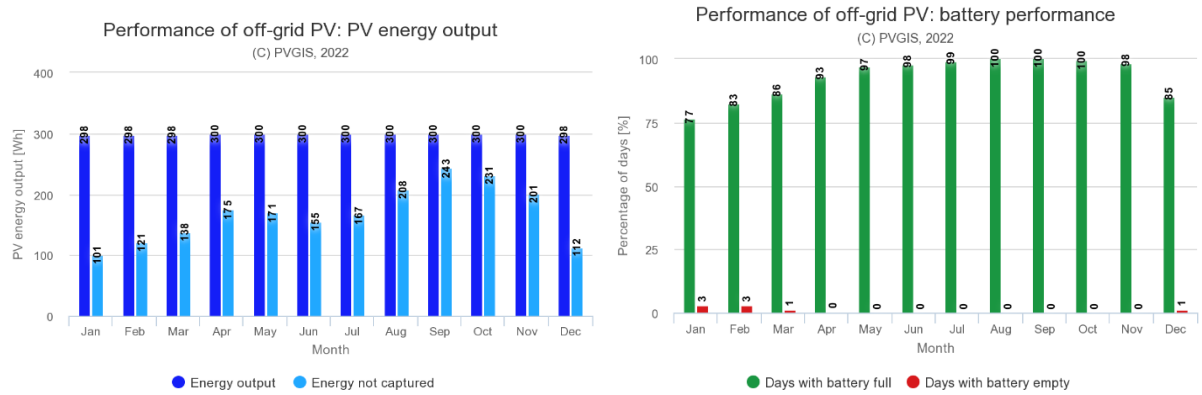

Figure 7. Simulation result of PV energy output and battery performance of SHS in 2021-2022

2.7. Evaluation of Installed SHS

Since the first project in 2019, questionnaires have been used to learn about the churches' situation before installation. The questionnaires were sent to a local contact and shared with the churches. The quality of the survey results was below the expectation since some respondents were not trained to read and file documents but had to fill out the questionnaire without help. Furthermore, the results were shared via instant messaging services and were often unreadable.

Based on this experience, an online questionnaire was developed to evaluate churches after the SHS installation. People from ten churches were interviewed face to face, with the data saved in an online database. Next to the location and biodata of the churches and contact persons, there were three questions mainly asked:

1. What is the status of the installation? What is working, and what is not working? Does the system produce enough electricity?
2. How is the electrification situation? Do you already have an electricity grid connection? Is a grid connection planned for this year?
3. How are you using the system? What are the benefits?

3. RESULTS

The interviews for this evaluation took place in March 2022. There were 14 SHS planned for evaluation using questionnaires and interviews, 9 SHS was visited directly by interview, 3 SHS information was obtained from local technicians and 2 SHS did not provide feedback and could not be visited due to the very remote location, but the electrical conditions of the SHS installation area is known. Percentages shown were based on the available amount of data.

3.1.1. What is the status of the installation? What is working, and what is not working? Does the system produce enough electricity?

Among the 12 systems covered in the survey, only five worked without problems. Seven systems did not have working lights. After checking the components, two churches did disconnect the switch box, and two churches did disconnect the solar battery and changed it to a small motorbike battery. It was found later that the motorbike battery was only temporarily connected to electricity use and in other areas for light.

Error analysis showed that all solar modules, all batteries, and all charge controllers were working fine. One charge controller had to be exchanged due to a bad thread for the battery connection.

In all cases of damaged solar systems, the main reason was broken LED light bulbs. Sometimes users replace the 12 V DC Light bulbs with 220 V AC light bulbs. The analysis was used to educate the user only to use 12 V DC lamps and warn them not to change cables without permission. Some systems built in 2019 were installed without a switch box and the information on the technician's contact number. It can be perceived that the main reason for the high failure rate in 2019 is that the installation was not carried out by trained installers.

Moreover, cables were not properly connected; the locals were not trained to use the system and how to troubleshoot the system. Besides, switch boxes were not installed, and no contact number for technical support was provided. As users experience electricity for the first time, simple things like changing a light bulb - especially a 12 Volt DC bulb - are challenging without advice or technical training. The following simplification was made to quantify the results: Light is working=1, and Light is not working= 0. Figure 8 shows that none of the 2019 installations worked at the evaluation time.

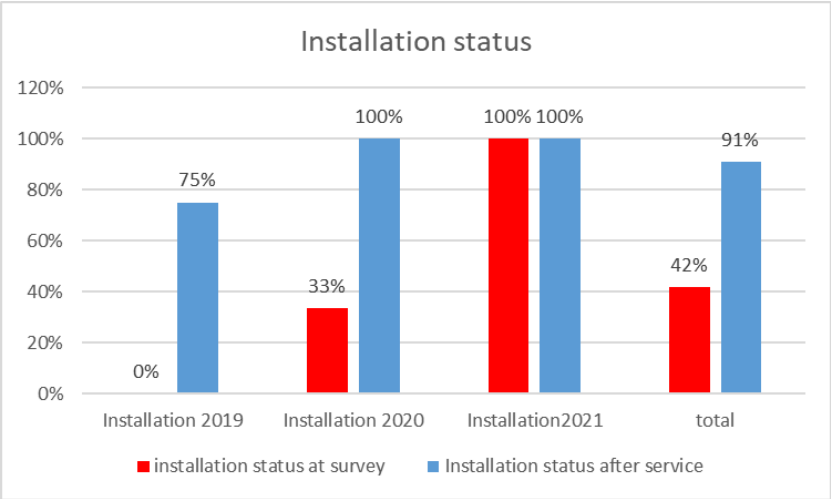

Figure 8. Percentage of installations that are fully working

After service, the number of running systems increased to 3 (75%) from 2019. One system was disconnected from an old building and not yet connected to the new building. The users mentioned that the building is used in the daytime. Furthermore, they are waiting for a grid connection this year. The survey and the subsequent service of defective systems could increase the installed running systems from 2019 - 2021 from 42% to 91% (11 of 12 systems).

3.1.2. How is the electrification situation? Do you already have an electricity grid connection? Is a grid connection planned for this year?

As mentioned earlier, the electrification ratio in Indonesia has been increasing fast in recent years. It is also reflected in the survey results, which can be seen in Figure 9. At the installation time, no location was connected to the electricity grid. Power poles were already installed in some places, but houses were not connected for several years. The electrification rate increased from 60% in 2017 to almost 90% in 2021. Users already connected to the grid still like to use the solar system as backup during frequently occurring power outages and to save electricity

costs. The church's system, connected to the grid from 2019, could be installed in a church without a grid connection (not included in Figure 9 below).

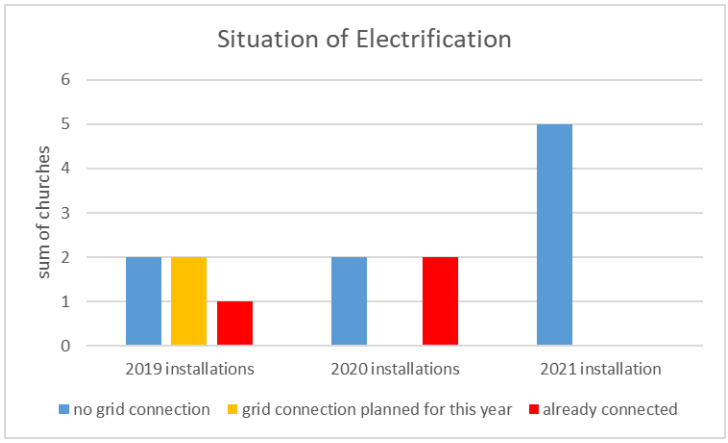

Figure 9. Current Situation of electrification of SHS installations

3.1.3. How are you using the system? What are the benefits?

The purpose of solar home systems installation in churches without grid connection is to support churches in their activities and serve the community. As mentioned earlier, electrification is key to increasing education and the economy. The third question should help to understand the usage and potential of the system.

Figure 10 shows that most churches mentioned using the system for evening church services and other evening activities from the church, like meetings and youth services. Depending on the church location, people often use the USB charger for phone charging, as five churches have mentioned. In villages without electricity, people often must go to a neighboring village to charge their phones. Four churches also mentioned using or wanting to use the system to have a learning center for students, especially in regions where homes also do not have electric lights. Two churches mentioned using or wanting to use the system so women can weave traditional Sumba cloth in the evening. It is crucial since Sumba cloth produced from the weaving activity can be sold at the local market or to tourists, increasing the economic situation. One church did not use the system as they only have services in the daytime.

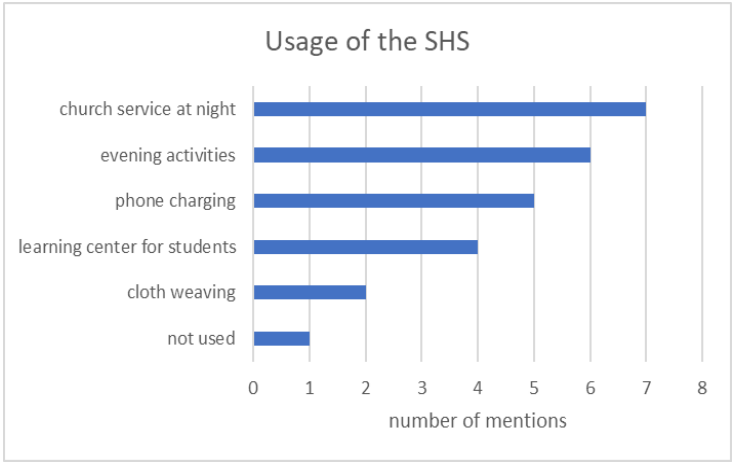

Figure 10. The usage of the SHS

4. DISCUSSION

A number of SHS was installed in 17 churches in Sumba and Timor and has been improved yearly to meet better the users' needs, e.g., by adding additional 12V outputs at the switch box. The system design was adapted to decrease the number of days with an empty battery from 16 to 8. Compared to a genset, the SHS is more economical and convenient as the user does not have to buy fuel and is not distracted by noise and pollution.

The first installation done by untrained technicians showed a high failure rate. Therefore, the installation quality was improved to reduce the system malfunctions for newer installations. Moreover, the most common reason for failure was defective DC lights. As a result of the evaluation, users need to be educated to use only 12V DC lights and contact the local technicians if the system is not working. In the future, the local technician will contact the users regularly to ask about the system's status to prevent downtime of SHS proactively.

Churches are chosen for SHS installation in this project since they are often used as gathering centers for people in NTT. The systems are used mostly for church evening activities, phone charging for the congregation, and learning activities for residents living around the church with permission from the church administrator. People are creative in ways of using it. Some church members also used the system for craft work and could increase their income. The usage of the system also depends on the location of the church. The community uses a church building close to neighboring houses more often than a stand-alone building.

The electrification ratio in Sumba has increased rapidly in the last few years. Therefore, to maximize the impact of SHS, the location should be selected more thoroughly to serve areas where no power grid is planned yet. Solar systems are still being used after PLN connection to save energy costs and as backup energy, as the grid connections are often unreliable, especially in rainy seasons. A contract needs to state that solar systems that are not “serving” the church anymore because of grid connection or lack of maintenance should be moved to a location with no grid connection and demand for the system.

Connecting the 100 Wp SHS to the grid is not recommended since it would involve more complex equipment and increase the project cost. Thus, for churches that PLN has electrified, it is suggested to move the systems to churches in greater need. However, if there is a church that can take good care of SHS and wants to continue using SHS, this is a good sign because it shows that the church already understands the benefits of SHS. They can use SHS to save on electricity costs and as a backup in the event of a power outage.

Active service is key for working systems that will impact the community. Some users do not use the service contact number for help but try to fix problems themselves. A more proactive service can prevent the installations from being misused and the system from malfunctioning. In the future, a good financing model should be developed so that small repairs can be financed by the user, leading to more sustainable use of the system.

5. CONCLUSION

Seventeen SHS were installed in Sumba and Timor churches and mostly used for evening activities, phone charging, and learning. From the study carried out in this paper, it can be concluded that installation quality and active service ensure a working system and high user satisfaction. Technical training for users to solve simple problems needs to be conducted. Moreover, the technician’s contact number also needs to be added so the users can contact the technician as soon as the system is not working properly. Furthermore, locations should be

more thoroughly investigated to estimate the possibility of grid connection in the short future to maximize the use of solar systems.

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INTEGRATING BUILDING INFORMATION MODELING (BIM) AND UNMANNED AERIAL VEHICLE (UAV) FOR BUILDING 3D MODELING: A CASE STUDY OF WISMA SRI MAHKOTA BENGKALIS

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ABSTRACT

The demand for geospatial information of a region grows in numerous sectors, as does the method of mapping operations. Various advanced technology has been utilized to support survey and mapping activities, including Unmanned Aerial Vehicles (UAVs). This study aims to develop a method to digitize building documentation by integrating the UAV in the Building Information Modelling (BIM) by considering a lodging property in Bengkalis regency as the case study. Orthophoto data obtained from processing aerial photos taken using three flight paths, namely Nadir, Oblique, and Circular, was used to develop the BIM 3D model. The accuracy of the developed BIM model was evaluated using the orthophoto data as the horizontal accuracy using the Root Mean Square Error (RMSE) metrics. The accuracy calculation of Point Cloud 3D resulted from the integration of BIM and UAV, resulting in RMSExy of 0.0834 m, a height ratio of 0.05, and Circular Error (CE) accuracy of 0.1265 m included in the Level of Detail (LOD) 3, confirming the high accuracy of BIM-UAV integration.

Keywords: Building Information Modelling (BIM), Unmanned Aerial Vehicle (UAV)

1. INTRODUCTION

Over the last decade, 3D digitization and geomatics technologies have entered the cultural heritage building documentation to meet the needs of preservation, management, and protection (Logothetis et al., 2015). It aims to ensure that the information regarding a cultural heritage entity's significant historical characteristics, such as its shape and appearance, is reserved in case of natural or other damages (Karachaliou et al., 2019). Various advanced technology has been utilized to obtain this objective, one of which is Building Information Modeling (BIM).

BIM is a process that leads to creating and managing a model that digitally represents a construction project, in which all the information regarding its characteristics is contained (Doumbouya et al., 2016). BIM 3D models in a particular Level of Detail (LOD) are the simplified versions of more complex models that use simple geometric primitives while retaining essential details (Pantoja-Rosero et al., 2022). While BIM can be used to create, manage, and share the lifecycle data of vertical facilities such as buildings, Geographic Information System (GIS) can be used to store, manage, and analyze data describing the urban environment (Ma & Ren, 2017).

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UAVs have become an extremely important tool for cultural heritage specialists to document and analyze cultural heritage sites and structures as they provide a cost-effective and efficient manner to acquire high spatial resolution data and generate reliable documentation on time (Hoon & Hong, 2019; Murtiyoso & Grussenmeyer, 2017; Themistocleous et al., 2016). On the other hand, BIM is well suited to modelling point clouds, the collections of high points in the thousands to millions of points resulting from photogrammetric processing of aerial photographs generated by geomatics procedures, such as UAV's photogrammetry (Barrile et al., 2019; Kim et al., 2021; Rizo-Maestre et al., 2020).

This study aims to develop a 3D model for an existing cultural building by integrating BIM and UAV, taking into account the Wisma Sri Mahkota building as the case study. Wisma Sri Mahkota is located at Antara Street of Bengkalis Regency in Indonesia's Riau Province. It is a government-owned lodging property designed with magnificent European architecture. The accuracy of the UAV-based 3D building modeling resulting in this study will be validated with several approaches, which include comparing the distance and height of the building object in the modeling with actual conditions using manual measuring equipment in the field.

2. METHODS

This study was conducted in two stages to obtain its objective of developing a 3D model of a building by integrating the BIM and UAV approaches. Figure 1 illustrates the location of Wisma Sri Mahkota in the Senggoro Village of Bengkalis, Riau, Indonesia.

Figure 1 Location of the Case Study

2.1. Pre-Field Stage

In this first stage, the Area of Interest (AOI) as the boundary was determined, and the distribution of Ground Control Point (GCP) and Independent Check Point (ICP) binding points was planned using Google Earth Pro software. Afterward, the flight path regarding AOI in KML/KMZ format was selected and converted into Pix4D Capture.

2.2. At-Field Stage

The measurement of the GCP binding point is 5 points, and the ICP object check binding point is 6 points. GCP and ICP binding points were measured using Global Navigation Satellite System (GNSS) Geodetic Trimble R8s Dual Frequency with the Networked Transport of RTCM via Internet Protocol (NTRIP), a Real-Time Kinematic (RTK) positioning correction transmission protocol. The measurement reference point uses Indonesia's Continuously Operating Reference Station (Ina-CORS) from the Geospatial Information Agency (GIA): Radio Technical Commission for Maritime (RTCM) of 0173 Apit River, Siak Sri Indrapura Regency, Riau Province (see Figure 3c), with coordinates (X= 183465.294, Y= 124140,477, Z= 8056 m (ellipsoid)).

Subsequently, the aerial photo data was taken using (see Figure 3b) UAV Multirotor DJI Phantom 4 Pro v 2.0 with 3 flight methods (Nadir, Oblique, and Circular). Aerial photo data capture is Nadir at an angle of 90º with a height of 50 meters, while the Oblique method focuses the camera at 60º with a height of 50 meters. Nadir and oblique aerial photos were taken automatically using the Pix4D Capture application. Furthermore, the Circular UAV flight method was flown using the free flight mission method or manually flying around the AoI to get 3D details of the building. The settings in the application pix4d were captured as follows: (a) altitude 50 m Above Ground Level (AGL); (b); side lap = 80%, overlap = 80%; (c) Area of Interest (AoI) = 112 m x 112 m, as shown in Figure 2.

(a)

(b)

Figure 2. GCP and ICP Distribution (a), Area of Interest (b)

(a) (b) (c)

Figure 3. Measurement of GCP coordinates (a), Drone DJI Phantom 4 Pro v2 (b), Cors GIA (c)

2.3. Data Processing

Agisoft Metashape Professional Version 1.7.0, photogrammetry software, was used to perform modeling processing. It can create 3D models of buildings from aerial photo data using UAVs. The steps for processing aerial photo data were as follows:

1) Align photo: a module that packs two methods: image matching and bundle adjustment.
2) Self-Calibration: A process during the align photos so that camera distortion parameters can be estimated, which can be applied to improve the quality of data processing results.
3) Geometric Correction: a process carried out with GCP data in previous measurements using geodetics. The GCP position seen on the premark is identified. Premark is a field mark that is placed at a point on the ground so that it can be seen on aerial photographs for the purpose of measuring control points.
4) Build Point Clouds: which were processed further to produce data in the form of 3D modelling, Digital Surface Model (DSM), Digital Terrain Model (DTM), and input materials in the Orthophoto manufacturing process, as well as 3D Point Clouds modelling, integrated with Autodesk Revit as the BIM application.
5) Build 3D Mesh: a process of 3D model development in Agisoft Metashape software as the basis for creating DEM, DTM, and DSM. Height Field and Arbitrary are parameters in this

process selected according to their function. Arbitrary parameters are used to get better building details.

6) Export Point Clouds: it was carried out to integrate modelling from aerial photographs into the BIM application. Point Clouds from Agisoft Metashape were exported to Autodesk Revit for further analysis. Export Point Clouds supports several formats, such as Rcp and Rcs.

7) Import Point Clouds to Autodesk Recap student license: converting the export point clouds data into *.RCP format, which was then imported into Autodesk Revit.

8) Import Point Clouds *RCP to BIM: the Points Clouds in *RCP format were imported into Autodesk Revit to see if they can be used as a reference for further development. Once imported, the object's colour, distance, and height can be seen.

Figure 4 and Figure 5 illustrate the stages and steps in the research workflow.

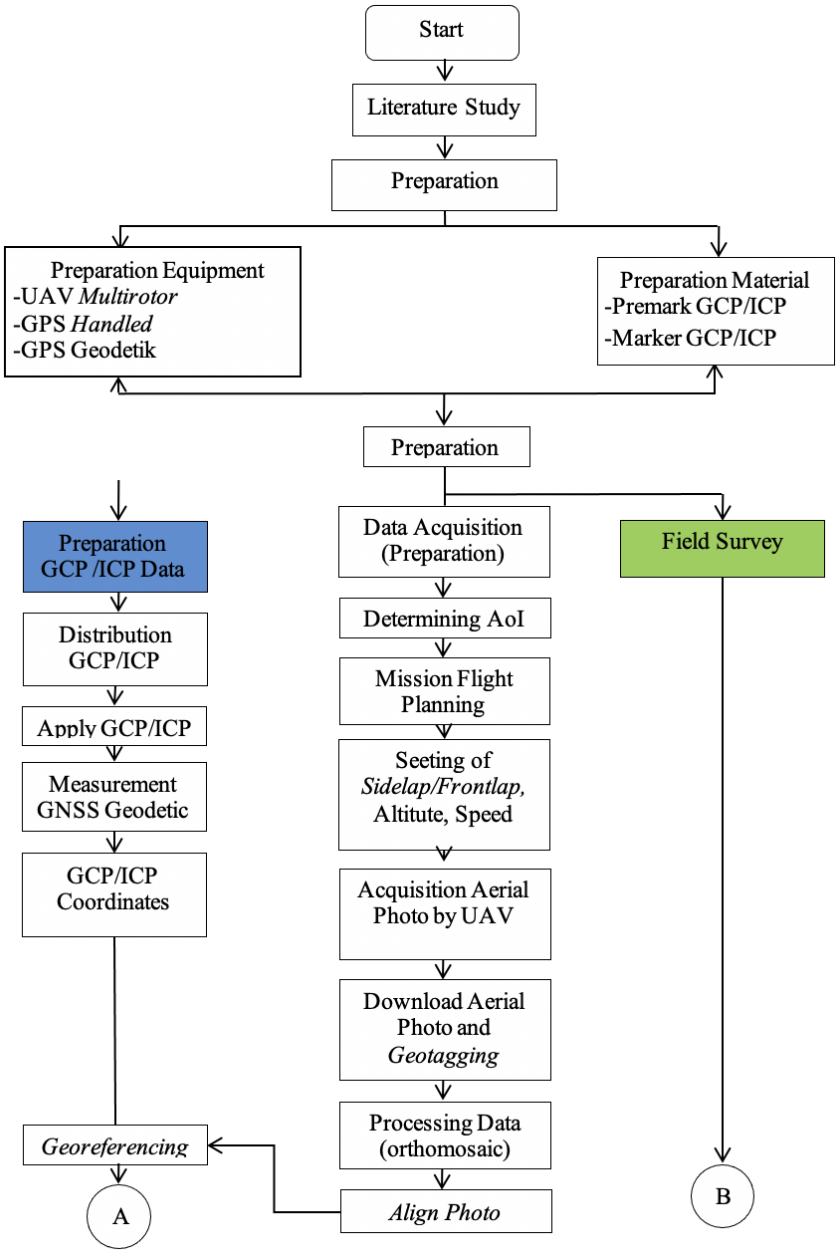

Figure 4 Research Workflow

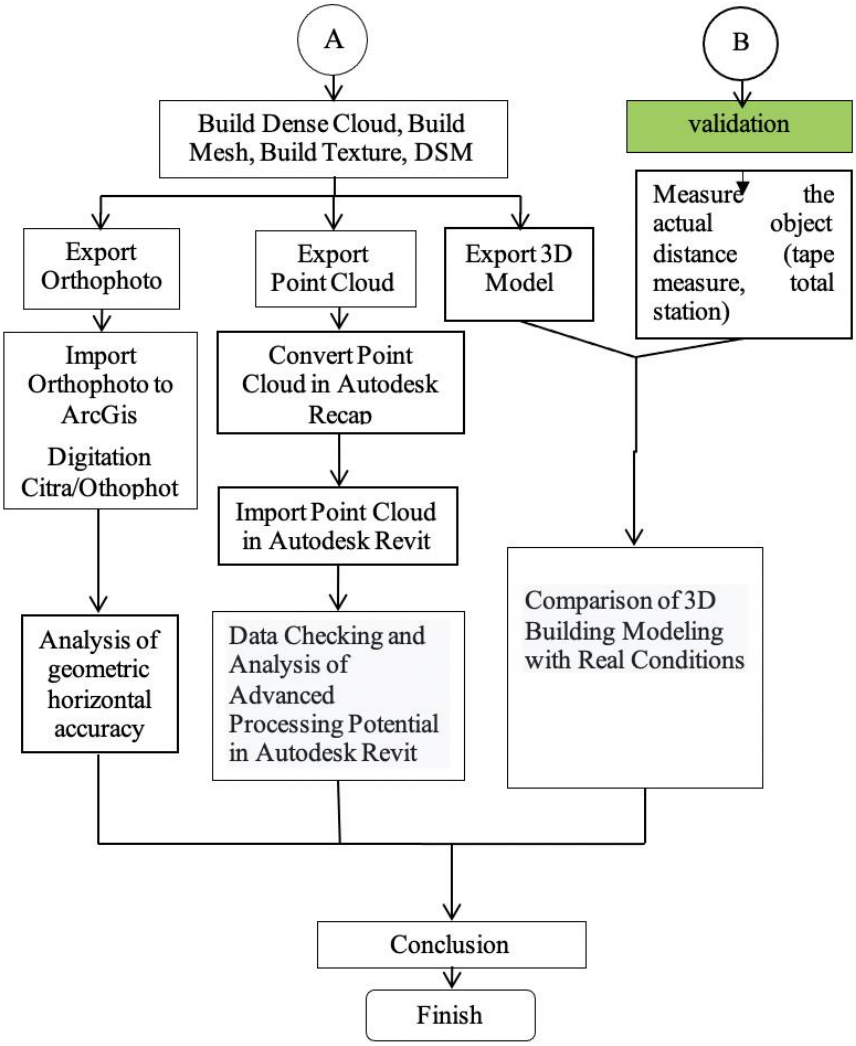

Figure 5 Research Workflow (continued)

3. RESULTS AND DISCUSSION

3.1. Fotogrammetry and GCP Data Acquisition

There were 272 photos from the Photogrammetric data acquisition using the DJI Phantom 4 Pro v2.0 Multirotor UAV, obtained by manual flight method and with pix4d capture flight path. GCP data acquisition was obtained using the Trimble R8s Geodetic GPS (see Table 1). The method of observation used was RTK-NTRIP observations with the Ina-CORS system.

Table 1 Position of object point (GCP)

Premark	Easting (X)	Northing (Y)	Elevation (Z)
GCP 1	179828.69	163358.643	2.903
GCP 2	179781.19	163297.215	2.994
GCP 3	179839.75	163250.841	2.96
GCP 4	179877.87	163313.62	3.183
GCP 5	179861.28	163273.228	3.234

3.3. Horizontal Accuracy

The horizontal position accuracy test refers to the difference in coordinates (X, Y) between the test point on the map and the actual test point on the ground surface (see Table 2). Measurement of accuracy using Root Mean Square Error (RMSE). RMSE is used to describe accuracy, including random and systematic errors; this RMSE can be calculated when the coordinate transformation is complete with the formula:

$$CE90 = 1{,}5175 \times RMSExy \quad (1)$$

$$(RMSE)\_xy = \sqrt{((2*((RMSE)x)^2)} \quad (2)$$

Table 2 The horizontal position accuracy (RMSE)

NO	Name	X Orthophoto (m)	X Field (m)	(DX)	(DX)²	Y Orthophoto (m)	Y Field (m)	(DY)	(DY)²	DX²+DY²
1	ICP 1	179819.7983	179819.785	0.013	0.000178	163272.0274	163271.997	0.030	0.000921	0.0011
2	ICP 2	179839.0181	179839.02	-0.002	0.000003	163270.5466	163270.531	0.016	0.000244	0.0002
3	ICP 3	179866.1696	179866.186	-0.016	0.000269	163329.9248	163330.025	-0.100	0.010039	0.0103
4	ICP 4	179843.7179	179843.766	-0.048	0.002315	163344.9476	163345.016	-0.068	0.004675	0.0070
5	ICP 5	179821.199	179821.335	-0.136	0.018487	163343.0792	163343.063	0.016	0.000263	0.0188
6	ICP 6	179790.5609	179790.552	0.009	0.000080	163309.3409	163309.276	0.065	0.004213	0.0043
								∑		0.0417
								Means		0.0069
								RMSExy		0.0834
								CE90		0.1265

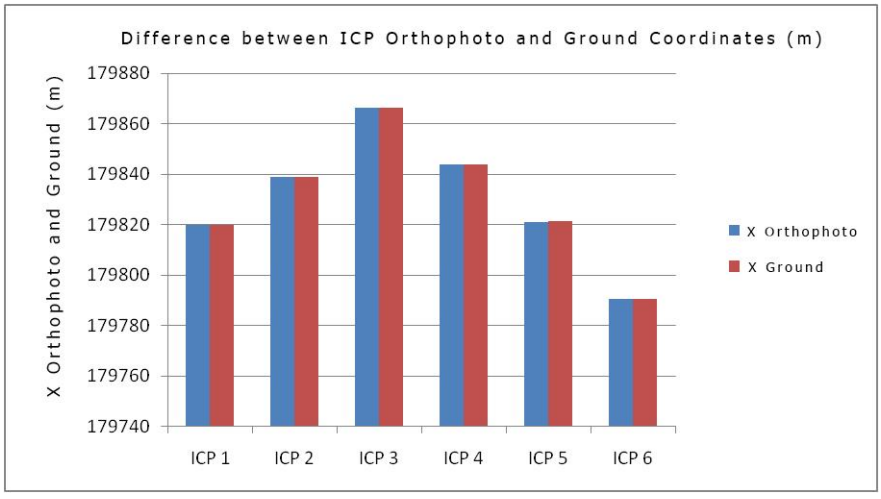

Figure 5 Comparison between orthophoto coordinates and Geodetic coordinates

Based on Table 2, the RMSExy value is 0.0834 m. The orthophoto accuracy value is the CE90 (Circular Error) value of 0.1265 for horizontal accuracy. It indicates that the orthophoto position error does not exceed the accuracy value and has a 90% confidence level obtained using the standard geometric accuracy.

3.4. Accuracy Test of Distance Measurement

The distance measurement accuracy test is carried out by comparing the distance on the orthophoto that has been rectified using the Ground Control Point (GCP) in the 48N zone UTM

coordinate system with the actual distance in the Field using a meter. The distance comparison between the aerial photographs and field measurements is summarized in Table 3.

Table 3 Accuracy of distance measurement in the field and orthophoto

No	Orthophoto	Field Check	Distance		Result
			Orthophoto (m)	Field (m)	
1			12	12	0
2			7.41	7.41	0
3			2.55	2.55	0
4			39.5	39.5	0

The results in the table above show that the size is to provide confidence and certainty as well as the accuracy of an image.

3.5. Level of Detail (LoD) Identification

Identifying the LOD was intended to determine the level of detail of the 3D model developed in the BIM application. Position accuracy, or the average difference in coordinates between the X orthophoto and X field, is 0.037333 m, while the difference between the Y orthophoto and Y field is 0.0491897 m. In addition, the altitude accuracy (z) is 0.03 m. Table 4 shows the identified LOD of the building.

Table 4 LOD identification

Geomatic Accuracy	Accuracy Result	Model	LOD Accuracy (m)
Horizontal X	0.037333	Architectural Models (exteriors) landmark	0.5
Horizontal Y	0.491897		
Height	0.03		

Table 4 above identifies that the 3D modeling of aerial photographs processed with Agisoft Metashape software meets the requirements to be classified at LOD 3.

3.6. Comparison between the Physical Building Height and the Model

The height comparison is made using the Focus-Spectra Total Station Measuring Tool by comparing the height data of field objects with data from aerial photo processing (see Figure 6). A total station in the field measurement was carried out by taking vertical angles and oblique distances in the field.

Figure 6 Altitude test point

Tabel 5 Altitude measurement results using total station

NO	HEIGHT OF EQUIPMENT(M)	VERTICAL ANGLE	HORIZONTAL ANGLE	SLOP DISTANCE (M)	ELEVATION (M)
1	1,103	68° 50' 43"	71° 34 54"	66,094	24,955
2	1,103	71° 34' 54"	214° 50 11"	63,569	21,187
3	1,103	73° 48' 42"	211° 29 2"	58,228	17,337
4	1,103	74° 55' 27"	200° 45 10"	64,032	17,757
5	1,103	78° 8' 14"	194° 46 4"	64,044	14,268
6	1,103	77° 10' 8"	221° 19 0"	37,644	9,462
7	1,103	78° 41' 59"	237° 14 3"	42,441	9,420

The data obtained at point 7 from the collection of altitude data using the total station are as follows:

Vertical Angle : 78°41’59”
Oblique Distance : 42,441 m
Height Equipment : 1,103 m

So that it can be searched with trigonometric formulas in the following way: (see Figure 7)

Cos 78°41’59” x 42.441 m = Tinggi +1.103 m
8.316 m = Height + 1.103 m
Height = 8.316 m + 1.103 m
Height = 9.419 m

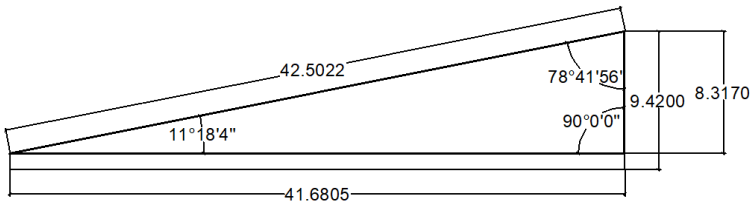

Figure 7 Angle calculation sketch

The results of height measurement conducted in the Agisoft Metashape can be seen in Figure 8.

Figure 8 Height measurement results in the Agisoft Metashape

Measurements with total stations were carried out at 2 points as a comparative analysis in the Field with the results of Aerial Photography, namely at points 6 and 7, with a comparison of accuracy summarized in Table 6, indicating that the physical building heights measured using a total station has an average difference of 0.03 cm.

Table 6 Altitude comparison measurement results at points 6 and 7

NO	Orthophoto (m)	Field (m)	
		Total Station	Tap Measure (manual)
1	9,55	9,462	9,45
2	9,43	9,420	9,42

3.7. Analysis of the Result of Import Point Clouds to BIM

A total of 272 photos taken at Wisma Sri Mahkota were processed with Agisoft Metashape. The point clouds generated by the Software were integrated into the BIM application using Autodesk Revit through the help of the Autodesk Revit Recap program (see Figure 9).

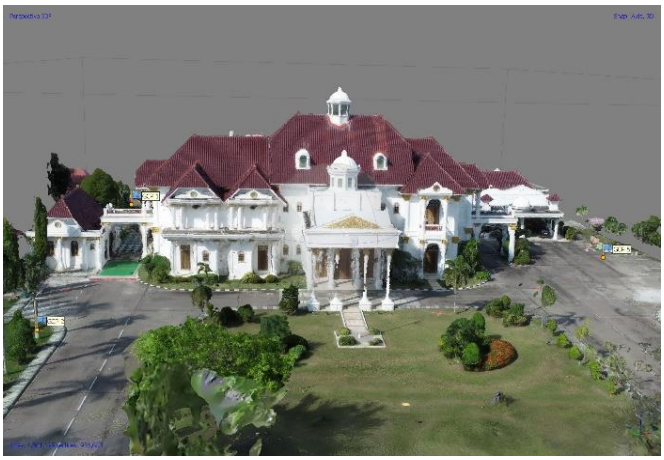

Figure 9 The 3D model of the case study

The modeling developed in Autodesk Revit provides sufficient information to be used as a reference for building reconstruction because the information obtained is in the form of color, height, etc. Figure 10 shows the results of the 3D point cloud model from Agisoft MetaShape Pro, and the 3D BIM Model imported by Autodesk Revit can be seen in Figure 11.

Figure 10 Point clouds 3D model from Agisoft Metashape Pro

Figure 11 3D BIM model imported from Autodesk Revit

4. CONCLUSION

Based on the study conducted on the Wisma Sri Mahkota Bengkalis building, the application of UAV aerial photography for 3D modeling can be utilized by taking into account several aspects, such as horizontal accuracy and distance accuracy. Furthermore, the requirements errors not exceeding the required conditions for aerial photography should be considered. From the results of this study, it can also be concluded that 3D modeling using Point Clouds as a result of processing UAV Aerial Photos can be integrated with BIM, where the integration can be seen in the form of color, coordinates, building height, and 3D points.

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